EARLY DEVONIAN (EMSIAN) AGGLUTINATED FORAMINIFERANS FROM BUCHAN AND BINDI, VICTORIA, AUSTRALIA

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Twenty-six genera and 45 species of Early Devonian (Emsian) agglutinated foraminiferans are described from the Taravale Formation and Buchan Caves Limestone from eastern Victoria. Three new genera, *Cystringarhiza*, *Patellammina* and *Cylindrammina* are described and 28 new species: *Cystringarhiza mawsonae*, *C. corona*, *C. tribracchia*, *C. furca*, *Astrorhiza triquetra*, *As. constans*, *As. sinus*, *Cylindrammina stolonifera*, *Hyperammina reflua*, *H. proboscis*, *Rhabdammina proavita*, *Saccorhiza surculus*, *Stomasphaera cyclops*, *Patellammina prona*, *Hormosina divitiae*, *Reophax troca*, *Lagenammina talenti*, *L. laxacolla*, *L. ovata*, *Lituotuba torquata*, *L. helix*, *Thurammina zaramama*, *Webbinelloidea crassus*, *Pelosina grandaeva*, *Kerionammina prolata*, *Tolypammina anguinea*, *T. tantula*, *Ammovertella calyx*.

THE FORAMINIFERANS described in this paper came from the Early Devonian Buchan Caves Limestone and the Taravale Formation of the Buchan and Bindi areas of East Gippsland, Victoria (Figs 1, 2).

No detailed work has been carried out on the Victorian Devonian foraminiferans although they have previously been mentioned by Chapman (1933) and Teichert & Talent (1958): Chapman (1933) described two species, one from Mitcham as *Trochammina busaria*, later referred by Conkin & Conkin (1968) to *Thuramminoides sphaeroidalis* Plummer, and one as *Hemigordius lilydalensis* (however this species is arenaceous and does not belong in the calcareous genus *Hemigordius*). Teichert & Talent (1958) quoted W. J. Parr in reporting the presence of very poorly preserved unidentified foraminiferans in acid residues of the Taravale Formation. Conkin & Conkin (1968) listed, without discussion, the presence of *Tolypammina* spp., *Sorosphaeroidea* sp. and *Hyperammina*(?) sp. from the Devonian Pyramid Member of the Buchan Caves Limestone at Bindi.

MATERIAL

Over the past few years Ruth Mawson (Macquarie University, N.S.W.) has studied the conodont faunas of the Taravale Formation from Buchan and Bindi areas of East Gippsland (Mawson 1987a). It was from the light flotation fraction of the acetic acid-digested limestones and marls of this material that the present study of the foraminiferan faunas was undertaken.

Approximately 350 samples were available with the sample size varying from about 30 g up to 250 g. Of these, fewer than 90 samples had any foraminiferans present at all and in only 14 samples were foraminiferans frequent. Specimens were picked from the residues as conventional flotation methods were not successful.

REGIONAL GEOLOGY AND STRATIGRAPHY

The extensive Lower Devonian sediments about Buchan and Bindi have been described in detail by Fletcher (1963), Gaskin (1933), Mawson (1987a), Mawson et al. (1985), Philip (1966), Talent (1956, 1965, 1967, 1969) and Teichert & Talent (1958). For detailed maps, locality data and stratigraphy for the samples studied here see Mawson (1987a) and Figs 1–3 herein.

Lithologically, the Taravale Formation consists of 'impure limestone nodules and irregular, discontinuous limestone beds in mudstones' (Mawson 1987a). The Buchan Caves Limestone, which underlies the Taravale Formation, consists essentially of basal dolomitic limestones overlain by dark, fine-grained calcarenites (Talent 1956, 1969). The Murrindal Limestone is a small lenticular limestone body deposited during a gradual regressive event (Talent 1989) and lies entirely within the *perbonus* Zone. The Buchan Caves Limestone is thought to have been deposited on a shallow, flat, wide shelf (the Buchan–Indi–Combienbar Shelf) (Talent 1965, 1969, 1989). Slow increases in depth occurred; in the Buchan area as demonstrated by the faunal changes (Talent 1956), and at Bindi where five conodont biofacies have been distinguished (Mawson et al. 1993).

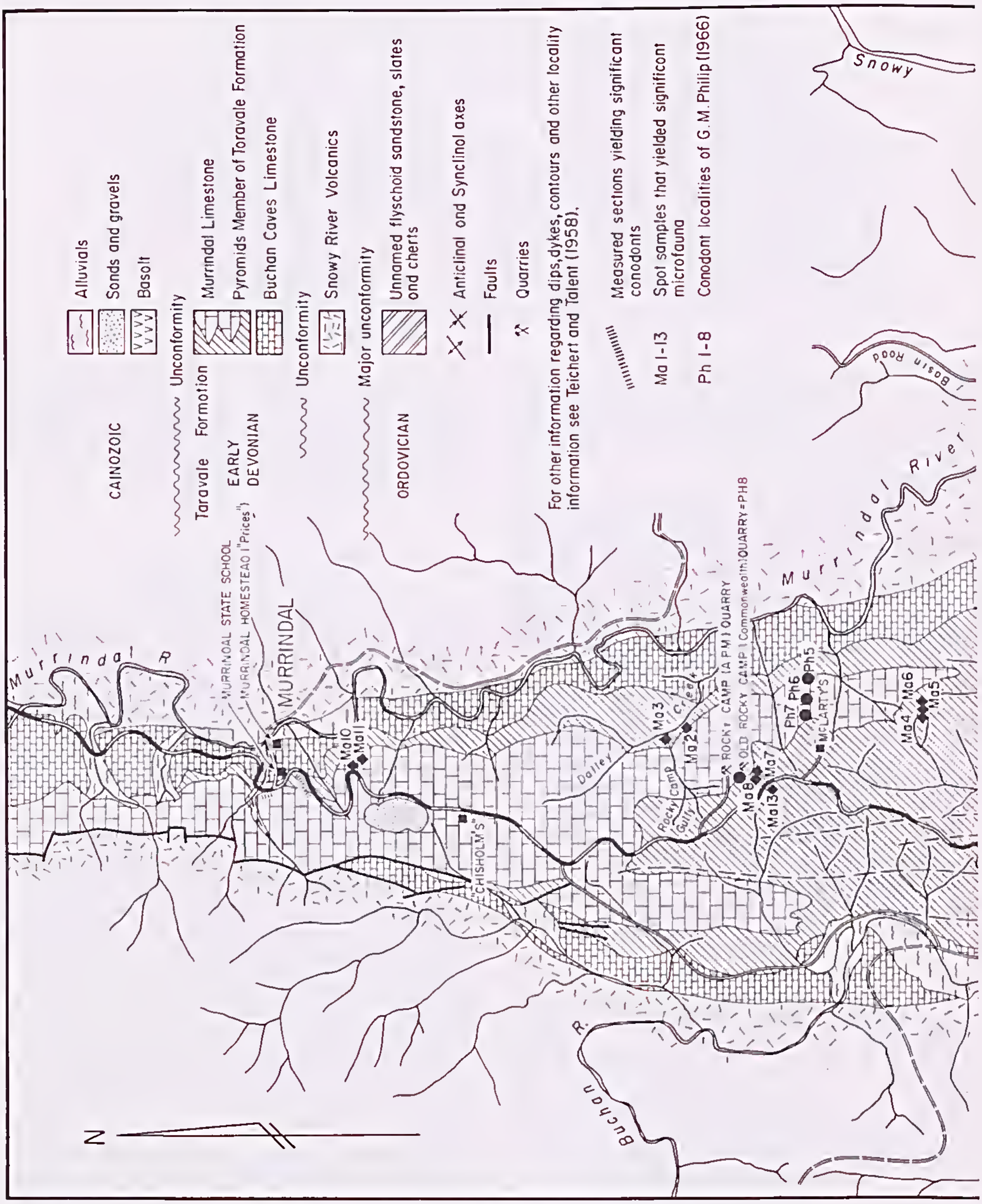
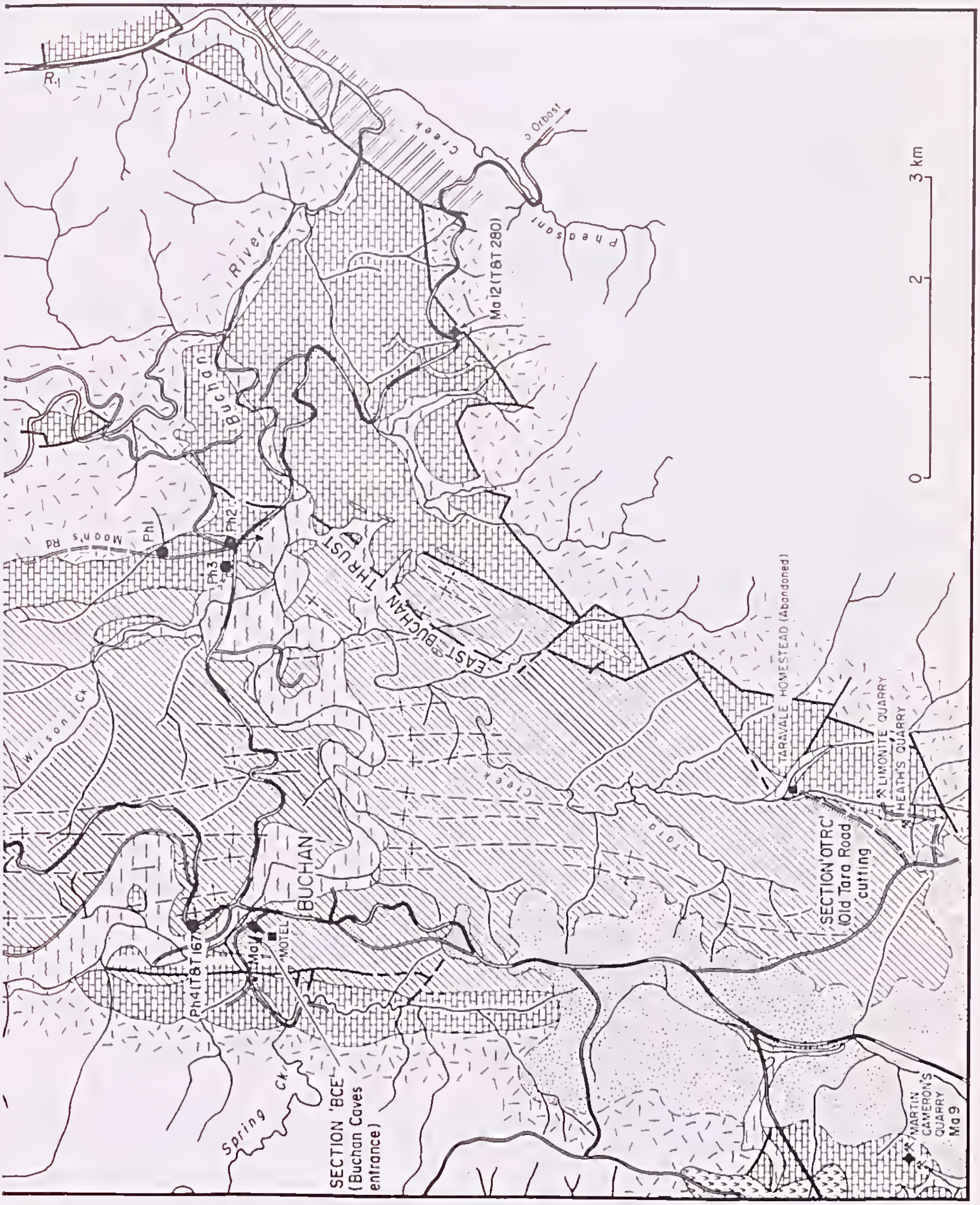
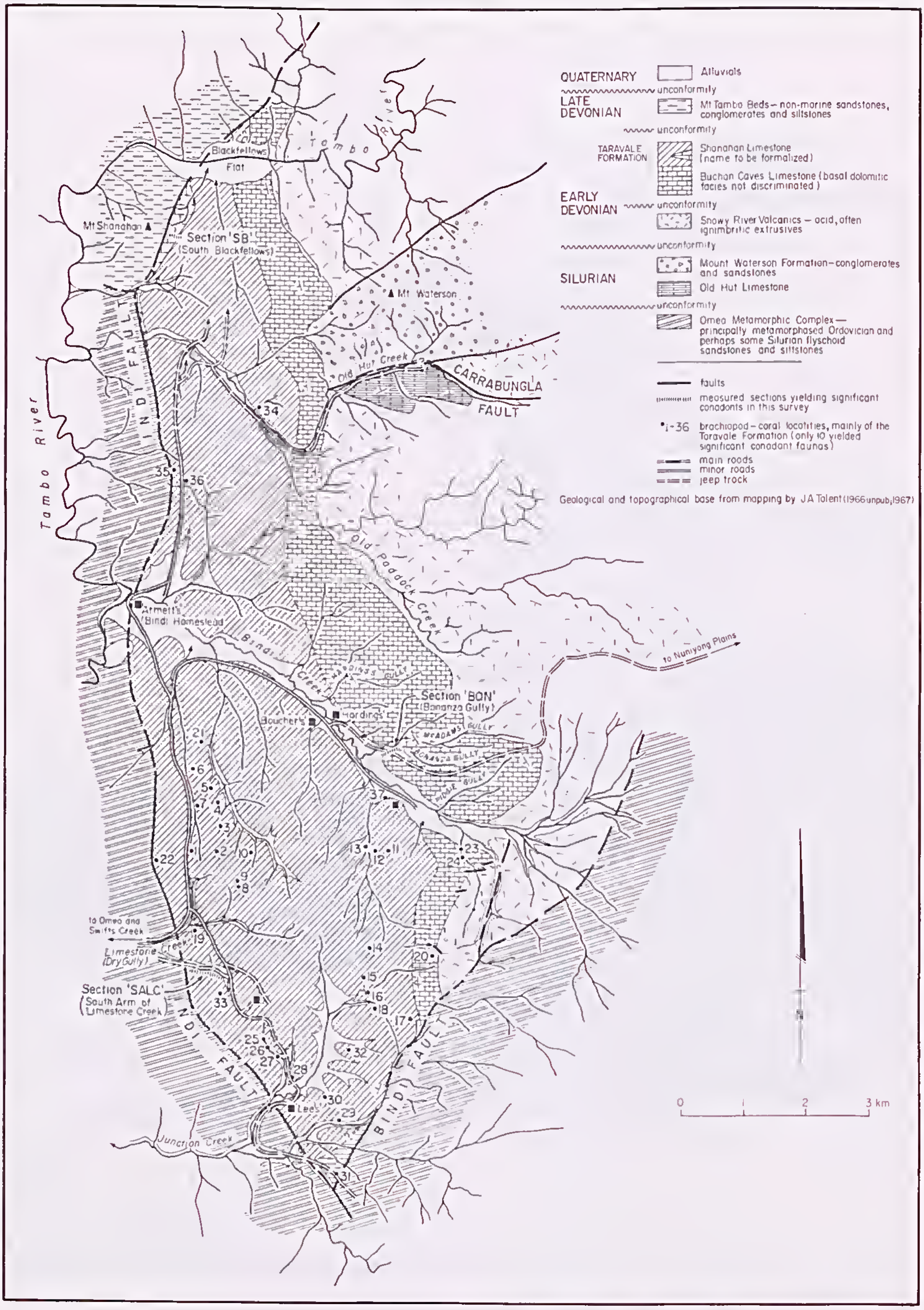


Fig. 1. The Buchan Group in the Buchan–Murrindal Area, Eastern Victoria, showing location of sample sites



OTRC, ORCQ and Ma 13 (after Mawson 1987).


QUATERNARY
Alluvials
unconformity
LATE DEVONIAN
Mt Tambo Beds – non-marine sandstones, conglomerates and siltstones
unconformity
TARAVALE FORMATION
Shanahan Limestone (name to be formalized)
Buchan Caves Limestone (basal dolomitic facies not discriminated)
EARLY DEVONIAN
unconformity
Snowy River Volcanics – acid, often ignimbritic extrusives
unconformity
SILURIAN
Mount Waterson Formation – conglomerates and sandstones
Old Hut Limestone
unconformity
Omea Metamorphic Complex — principally metamorphosed Ordovician and perhaps some Silurian flyschoid sandstones and siltstones
faults
measured sections yielding significant conodonts in this survey
1-36 brachiopod – coral localities, mainly of the Taravale Formation (only 10 yielded significant conodont faunas)
main roads
minor roads
jeep track
Geological and topographical base from mapping by J.A. Talent (1966 unpub; 1967)
Tambo River
Blackfellows Flat
Mt Shanahan
Section 'SB' (South Blackfellows)
Mt. Waterson
Old Hut Creek
CARRABUNGLA FAULT
BINDI FAULT
Old Paddock Creek
Armett's (Bindi Homestead)
Bindi Creek
Section 'BON' (Bonanza Gully)
Boucher's
Hardings
to Nuniyong Plains
to Omeo and Swifts Creek
Limestone Creek (Dry Gully)
Section 'SALC' (South Arm of Limestone Creek)
Lees
Junction Creek
0 1 2 3 km

The Taravale Formation represents a diachronous transgressive phase which took place during the *dehiscens* Zone at Buchan but which occurred within the *perbonus* Zone at Bindi (Mawson 1987a). There occurred a greater input of insoluble clastic material leading to the deposition of impure limestones and mudstones. VandenBerg (1988) has suggested that this was due to uplift of the Buchan–Indi–Combienbar Shelf. He also suggested that the Rocky Camp Limestone was a very shallow-water carbonate bank.

These sediments contain a diverse marine fauna of brachiopods (Talent 1956), molluscs (Talent 1956; Teichert & Talent 1958), ostracoda (Krommelbein 1954), corals (Hill 1950; Pedder 1967a, 1967b), ammonites (Teichert 1948), stromatoporoids (Ripper 1937; Webby et al. 1993) and conodonts (Mawson 1987a; Philip 1966).

The early studies pointed to an Emsian age; with the more detailed conodont studies (Mawson et al. 1985; Mawson 1987a) it is now known that these sediments belong to the *dehiscens*, *perbonus–gronbergi*, *inversus* and *serotinus* zones of the Early Devonian, i.e. upper Pragian to upper Emsian Stages.

The foraminiferans described herein, with about 70% being regarded as new species, represent an assemblage that is endemic, as far as is presently known, to the Buchan–Bindi area. Therefore they cannot of themselves serve as an aid for stratigraphical correlation.

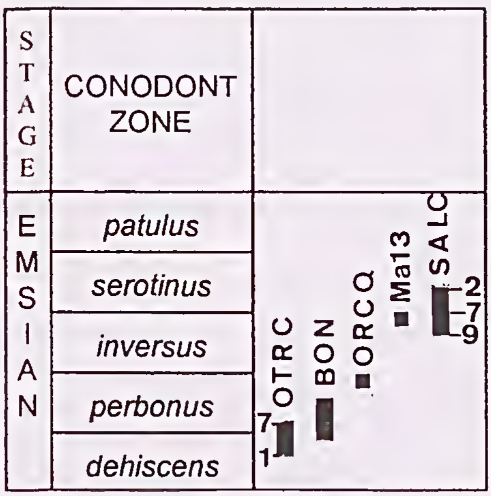


Fig. 3. Stratigraphic ranges of the Emsian (Early Devonian) sequences investigated in this report. For detailed stratigraphic information see Mawson (1987a).

AGES OF SECTIONS STUDIED

Old Taravale Road cutting (OTRC): *Polygnathus dehiscens dehiscens* occurs throughout this section but whilst forms transitional to *P. perbonus* are present, *P. perbonus* itself does not occur (Mawson 1987a). Thus this section lies wholly within the *dehiscens* Zone.

Bonanza Gully, Bindi (BON): In this section *P. dehiscens dehiscens* is found in a short interval from sample 25–27.5 (123.9–125 m above base) to sample 46–50 (129.6–131.5 m above base) with *P. perbonus* first occurring in sample 46–50 and persisting in higher samples (Mawson et al. 1993). In samples below the first occurrence of *P. dehiscens dehiscens*, *Ozarkodina prolata* is common and, as this species is not known to occur in sediments below the *P. dehiscens* Zone (Mawson 1987b), the BON sequence ranges from the *dehiscens* to *perbonus* zones.

Ma 13, Gelantipy Road: This sample is the same as 28 on the Gelantipy Road section (Mawson 1987a). Elements of forms transitional to *P. inversus* and of *P. inversus* occur thus placing it within the *inversus* Zone; *P. pseudoserotinus* which is broadly coeval with *serotinus* (Mawson 1987a) first occurs some 250 m stratigraphically higher.

Old Rocky Camp Quarry (ORCQ): This sample came from 10–15 m above the top of the Murrindal Limestone and is considered to be at the very top of the *perbonus* Zone (J. A. Talent, pers comm.).

South arm, Limestone Creek (SALC): The lower part of this section (samples 8, 9) yielded no conodonts but the upper part (samples 7-2) contained elements transitional to *P. setotinus* with samples 6-4 containing *P. serotinus* (Mawson 1987a); thus this section is considered to straddle the *inversus–serotinus* boundary.

SYSTEMATIC PALAEONTOLOGY

All types and figured specimens have been deposited in the Palaeontological collections of the Museum of Victoria, registered numbers prefixed NMV P.

Note on the term *proloculum*: In recent years there has been a tendency to call the initial chamber of a foraminiferan test the proloculus (e.g. Loeblich & Tappan 1994). However Cushman

Fig. 2. The Buchan Group in the Bindi Area, Eastern Victoria, showing location of sample sites BON and SALC (after Mawson 1987).

	OTRC			BON								ORCQ	Ma13	SALC		
	2	5	7	13-15	29-35	36-39	39-44	56-60.5	60.5-65	206	220-240	10-15		9	7	4
Astra. triquetra			x										x	x		
Astra. constans				x								x		x	x	
Astra. sinus												x			x	
Cyst. mawsonae													x	x		
Cyst. tribracchia												x		x		
Cyst. corona												x	x	x	x	
Cyst. furca												x		x	x	x
C. stolonifera						x						x		x	x	
R. linearis				x									x		x	
R. proavita			x													
S. surculus												x				
H. reflua		x	x			x						x				
H. proboscis												x	x			
H. sp.												x				
P. cava	x		x													
S. sp.cf. S.confusa	x	x	x													
S. cylindrica	x															
S. biosculata												x				
S. cumberlandiae						x										
L. sphaerica				x									x	x	x	

	OTRC			BON								ORCQ	Ma13	SALC		
	2	5	7	13-15	29-35	36-39	39-44	56-60.5	60.5-65	206	220-240	10-15		9	7	4
L. stilla													x			
L. talenti												x	x		x	
L. laxacolla						x							x	x	x	
L. ovata												x		x		
S. cyclops											x					
O. eisenacki				x								x				
P. grandaeva												x	x			
T. echinata		x	x			x						x				
T. subsphaerica		x	x	x								x				
T. tributa							x	x								
T. foerstei												x				
T. zaramara									x			x				
Hemisph. sp.			x													
W. crassus										x	x					
M. tholus				x												
P. prona											x					
K. prolata			x									x				
T. anquinea		x	x	x	x	x						x	x			
T. tantula				x	x	x						x				
A. calyx				x								x				

Table 1 continued next page.

	OTRC			BON								ORCQ	Ma13	SALC		
	2	5	7	13-15	29-35	36-39	39-44	56-60.5	60.5-65	206	220-240	10-15		9	7	4
T. torquata			x	x												
L. helix		x														
H. divitiae											x					
R. troca			x													
Th. sphaeroidalis	x	x	x									x	x		x	x

Table 1. Distribution of species within samples.

(1905: 538) defined the initial chamber as the proloculum. This definition has been followed in this paper.

The suprageneric classification follows Loeblich & Tappan (1988).

Order FORAMINIFERIDA Eichwald, 1830

Suborder Textulariina Delage & Hérouard, 1896

Family ASTRORHIZIDAE Brady, 1881

Genus Astrorhiza Sandahl, 1858

Astrorhiza triquetra n.sp.

Fig. 5A, B

Description. Test free; central body chamber is triangular and slightly inflated, the sides are of equal length; an arm issues from each corner of the central chamber, these stolons lie in one plane and are short, less than half side length; aperture is a simple opening at the end of each stolon; test wall formed of small quartz grains, with little cement, smoothly finished.

Holotype. NMV P126952, from Gelantipy Road, Buchan, sample Ma 13, Taravale Formation.

Measurements
Holotype NMV P126952 body diameter 0.3 mm
Paratype NMV P199385—Ma 13, 0.46 mm
Paratype NMV P199386—SALC 9, 0.25 mm
Paratype NMV P199387—OTRC 7, 0.39 mm

Distribution. Ma 13, OTRC 7, SALC 9; *dehiscens-inversus* Zones.

Remarks. The stolons are usually short, most likely due to breakages after death, as occasionally they are longer (equal to side length) and slightly curved, which may indicate that they were flexible in life.

A. triquetra differs from the Recent *A. triangularis* Earland 1933 from South Georgia in having stout arms, a smaller body chamber with less inflated sides and a much smoother surface.

Derivation of name. triquetra (Latin): three cornered; referring to the triangular shaped body chamber.

Astrorhiza constans n.sp.

Fig. 5C, D

Description. Test free; large, slightly inflated body chamber, with six coplanar stolons issuing more or less regularly about the periphery; the stolons are short and thick, slightly flaring at the

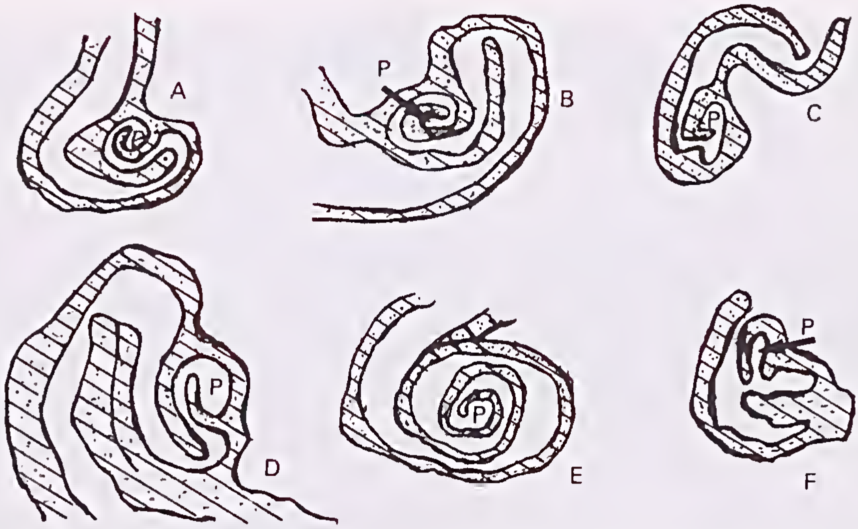


Fig. 4. *Ammovertella calyx* Bell n.sp. Schematic outlines showing the variation in growth pattern. P, proloculum (various magnifications).

apertural end; the aperture is a simple opening at the end of each stolon; the test is formed of small quartz grains, with little cement, and fairly smoothly finished.

Holotype. NMV P126953, from south arm, Limestone Creek, Bindi, sample 7, Taravale Formation.

Measurements
Holotype NMV P126953, body diameter, 0.4 mm
Paratype NMV P199388—BON 13.5–15, 0.34 mm
Paratype NMV P199389—SALC 7, 0.3 mm
Paratype NMV P199390—ORCQ 10–15, 0.6 mm

Distribution. SALC 7, SALC 9, BON 13.5, ORCQ 10–15; *perbonus–inversus* zones.

Remarks. This species differs from *A. triquetra* n.sp. in the number of arms and the shape of the body chamber, and from *A. sinus* n.sp. by the shape of the stolons.

Specimens referred to this species from BON 13.5 and SALC 9 often have one or more stolons stouter than the others and the placement of the arms is then not as regular about the periphery.

Derivation of name. *constans* (L.): consistent; referring to the regular placement of the stolons.

Astrorhiza sinus n.sp.

Fig. 5E–G

Description. Test free; body chamber discoidal, with five stolons issuing from one side of the chamber; the stolons are long, narrow and may be curved; a simple aperture at the end of each stolon; test wall formed of fine quartz grains with little cement, fairly smoothly finished surface.

Holotype. NMVP 126954, from south arm, Limestone Creek, Bindi, sample 7, Taravale Formation.

Measurements
Holotype NMV P126954, body diameter, 0.38 mm
Paratype NMV P199391—ORCQ 10–15, 0.48 mm

Distribution. SALC 7, ORCQ 10–15, BON 13.5–15; *perbonus–inversus* zones.

Remarks. In the holotype there is only one long, sinuous stolon, the others are short due to breakages, but in specimen NMV P126955 from ORCQ 10–15 two stolons are long and curved, one being somewhat flattened. It is thus possible that all the stolons were originally long and sinuous.

A. sinus n.sp. differs from *A. constans* n.sp. in the body chamber and arm shape and placement and from *A. triquetra* n.sp. in the body shape.

Derivation of name. *sinus* (L.): winding; referring to the shape of the stolons.

Genus Cystingarhiza n. gen.

Genotype. *Cystingarhiza mawsonae* n.sp. NMV P126956, from south arm, Limestone Creek, Bindi, sample 9, Taravale Formation.

Description. Test free, small, globular to ovate; consisting of a single spherical or subspherical chamber with few (2–6) radiating tubular extensions, not all in the same plane; wall agglutinated of small to medium sized sand grains with little cement visible; apertures at open ends of the tubular extensions.

Distribution. Early Devonian (Emsian; *perbonus–serotinus* zones) of Eastern Australia.

Remarks. This new genus has been erected to accommodate *Astrammina*-like specimens known only from the Early Devonian of Victoria. The genus *Astrammina* Rhumbler (in Wiesner 1931) was erected to accommodate *Astrorhiza*-like specimens but which had a globular, not flattened, central chamber and fewer arms. *Astrammina* is only known from the Holocene in the Antarctic, South Atlantic and South Pacific (Loeblich and Tappan 1988). *Cystingarhiza* differs from *Astrammina* in the much smaller size (about one-quarter to one-tenth diameter) and in having the stolons usually not in the one plane.

Conkin et al. (1968) have suggested that *Thurammina*? *triradiata* Gutschick & Treckman emend. Conkin, Conkin & Canis, of the Mississippian of the U.S.A., may be better referred to *Astrammina* (i.e. the new *Cystingarhiza*), because it has long tubular processes whereas *Thurammina* has smaller stubby papillae.

Derivation of name. *kystrix* (Greek, f.): a cell + *rhiza* (Gk): a root.

Cystingarhiza mawsonae n.sp.

Fig. 5I, J

Description. Test free; moderate size; central chamber globular with five radiating stolons which taper slightly aperturally; simple aperture at the ends of each stolon; test composed of small quartz grains with little cement; coarsely finished.

Holotype. NMV P126956, from south arm, Limestone Creek, Bindi, sample 9, Taravale Formation.

Measurements

Holotype NMV P126956, body chamber diameter 0.24 mm
Paratype NMV P199392—SALC 9, 0.3 mm
Paratype NMV P199393—Ma 13, 0.35 mm

Distribution. SALC 9, Ma 13; *inversus* Zone.

Remarks. The stolons are of variable length due to breakage and range up to equal in length to the central chamber diameter.

Derivation of name. For Dr Ruth Mawson, Macquarie University, for her contributions to the knowledge of Devonian biostratigraphy in Australia.

Cystingarhiza corona n.sp.

Fig. 5K, L

Description. Test free; moderate size; globular central chamber with four radiating stout stolons which issue from one cap of the central chamber; stolons short, about one-third of central chamber diameter; wall composed of fine grains with little cement, surface coarsely finished; aperture not observed on holotype but is a simple opening at the end of each stolon in other specimens.

Holotype. NMV P126957, from south arm, Limestone Creek, Bindi, sample 9, Taravale Formation.

Measurements (in mm)	diam.	arms	aperture
Holotype NMV P126957	0.3	0.09	0.05
Paratype NMV P199394—ORCQ	0.6	0.3	0.12
Paratype NMV P199395—Ma 13	0.43	0.12	0.05
Paratype NMV P199396—SALC 7	0.6	0.18	0.1

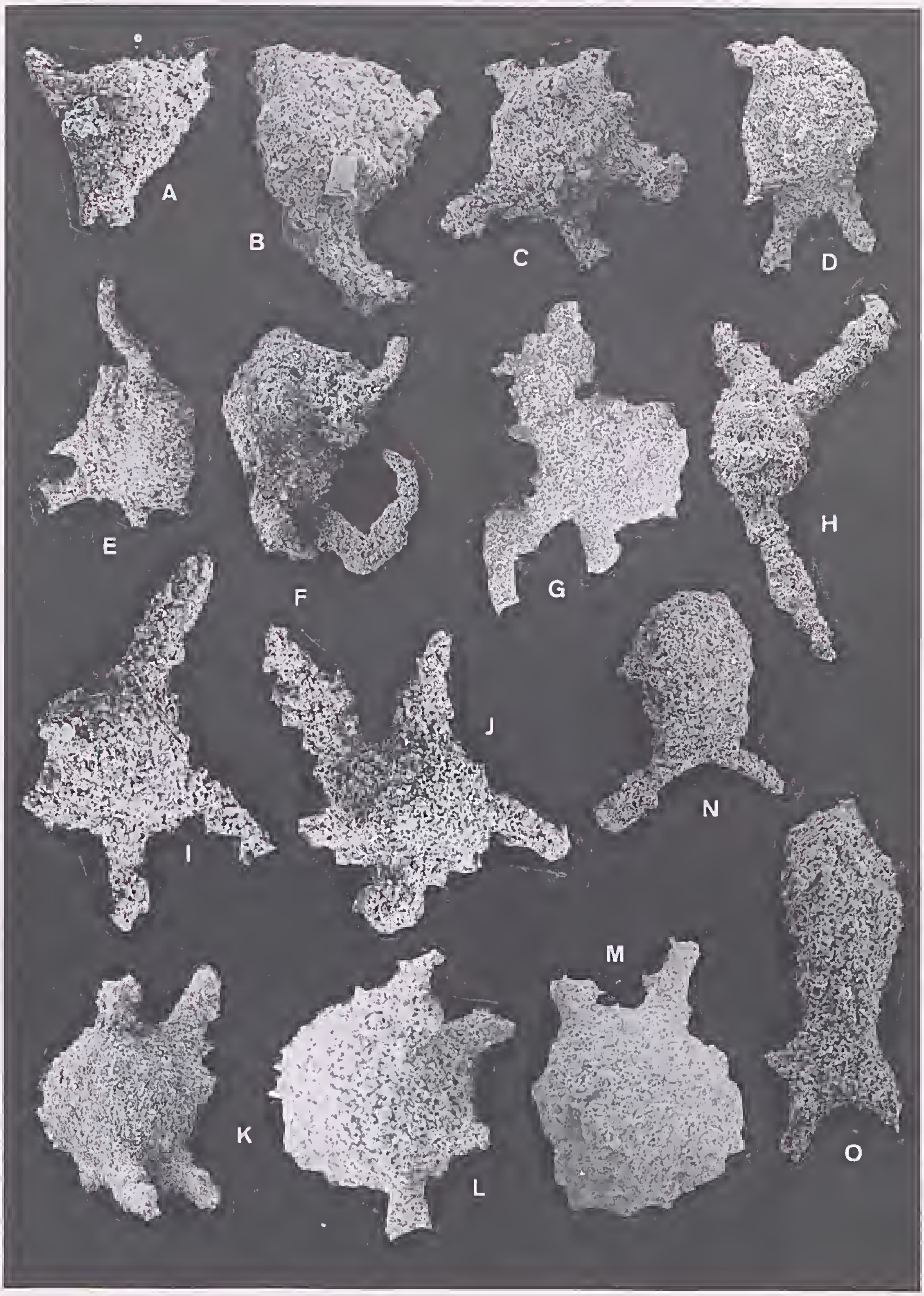
Distribution. SALC 7, SALC 9, Ma 13, ORCQ 10–15; *perbonus-inversus* zones.

Remarks. The degree to which the stolons are coplanar varies greatly; in the holotype the arms are almost in one plane whereas in specimens from ORCQ 10–15 the arms are highly angled with respect to the main chamber.

Specimens having only two or three arms are recorded as separate species.

Derivation of name. *corona* (L.): crown; referring to the stolons encircling one cap of the chamber.

Fig. 5. A–B, *Astrorhiza triquetra* Bell n.sp. A, Holotype NMV P126952, ×72, Ma 13. B, Paratype, NMV P199387, ×72, OTRC 7. C–D, *Astrorhiza constans* Bell n.sp. C, Holotype, NMV P126953, ×54, SALC 7. D, Paratype, NMV P199388, ×60, BON 13.5–15. E–G, *Astrorhiza sinus* Bell n.sp. E, Holotype, NMV P126954, ×45, SALC 7 F, Paratype, NMV P199391, ×63, ORCQ 10–15. G, Paratype, NMV P126955, ×36, BON 13.5–15. H, *Cystingarhiza tribrachia* Bell n.sp., holotype, NMV P126958, ×72, ORCQ 10–15. I–J, *Cystingarhiza mawsonae* Bell n.sp. I, Holotype, NMV P126956, ×90, SALC 9. J, Paratype, NMV P199392, ×72, SALC 9. K–L, *Cystingarhiza corona* Bell n.sp. K, Paratype, NMV P1999394, ×36, ORCQ 10–15. L, Holotype, NMV P126957, ×90, SALC 9. M–O, *Cystingarhiza furca* Bell n.sp. M, Paratype, NMV P199398, ×90, SALC 7. N, Holotype, NMV P126959, ×63, SALC 7. O, Paratype, NMV P199399, ×72, SALC 7.


A
B
C
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Cystingarhiza tribracchia n.sp.

Fig. 5H

Description. Test free; a small globular chamber from which issues three coplanar stolons; stolons are long, upto twice the body chamber diameter in length, narrow; aperture not observed.

Holotype. NMV P126958, from Old Rocky Camp Quarry, Buchan, sample 10–15 m above the top of Murrindal Formation; Taravale Formation.

Measurements (in mm)	diam.	arm	aperture
Holotype NMV P126958	0.1	0.3	0.05
Paratype NMV P199397–SALC 9	0.09	0.2	0.08

Distribution. ORCQ 10–15, SALC 9; *perbonus–inversus* zones.

Remarks. Tests are known from internal casts only. This species, which could be placed in the genus *Astrorhiza* because of its coplanar stolons, however appears to form a connecting link between *C. mawsonae* (5 stolons) and *C. furca* (2 stolons). Whether the number of stolons is a sufficient character to differentiate these species must await more and better preserved material. Specimens from SALC 9 show curving stolons.

Derivation of name. *tres* (L.): three; *bracchium* (L.): arm-like.

Cystingarhiza furca n.sp.

Fig. 5M–O

Description. Test free; body chamber ellipsoidal, slightly compressed at one end from which issues two stolons; stolons straight and narrow; aperture a simple opening at the end of each stolon; wall is fine grained with little cement, surface smoothly finished.

Holotype. NMV P126959, from south arm, Limestone Creek, Bindi, sample 7, Taravale Formation.

Measurements (in mm)	length × width	arm	aperture
Holotype NMV P126959	0.39×0.26	0.19	0.09
Paratype NMV P199398 –SALC 7	0.60×0.26	0.15	0.06
Paratype NMV P199399 –SALC 7	0.45×0.36	0.15	0.09
Paratype NMV P199400 –SALC 7	0.32×0.31	0.13	0.05
Paratype NMV P199401 –ORCQ	0.38×0.16	0.07	0.05

Distribution. SALC 7, SALC 9, SALC 4, ORCQ 10–15; *perbonus–serotinus* zones.

Remarks. This species shows much variation both in the shape and inflation of the central chamber and in the divergence angle between the two stolons. The body chamber ranges from quite elongate to almost spherical with subquadrate forms present also. These do not seem to be preservational differences but morphological variations within the species. The angle of divergence between the two stolons varies from 40° to 113°.

Genus Cylindrammina n. gen.

Genotype. *Cylindrammina stolonifera* n.sp. NMV P126994, from south arm, Limestone Creek, Bindi, sample 7, Taravale Formation.

Description. Test free; consisting of an inflated tubular chamber usually slightly curved, from which protrude several (2–10) thin, short stolons; wall composed of fine grains, thin, with a slightly rough exterior but smooth interior; a simple aperture occurs at the end of each stolon.

Remarks. *Cylindrammina* n. gen. differs from both *Astrorhiza* and *Cystingarhiza* n.gen. in the tubular shape of the test which can be quite variable in degree of curvature and amount of inflation. It also differs from *Astrorhizoides* Shchedrina, 1969 which consists of a thick, branching tube unlike *Cylindrammina* n. gen. which is a slender, usually curved tube with short thin stolons. The number of stolons per test also is variable within a population from any one sample, varying from two to ten; the stolons appear to be placed at random over the test.

Cylindrammina stolonifera n.sp.

Fig. 6A–C

Description. As for genus.

Holotype. NMV P126994, from south arm, Limestone Creek, Bindi, sample 7, Taravale Formation.

Measurements (in mm)	length	width	stolons no.	diam.
Holotype NMV P126994	0.72	0.3	8	0.06
Paratype NMV P199402 –SALC 7	0.72	0.3	2	0.06
Paratype NMV P199403 –ORCQ	0.8	0.6	4	0.16
Paratype NMV P199404 –SALC 9	0.78	0.21	3	0.1

Distribution. SALC 7, SALC 9, ORCQ 10–15, BON 36–39; *dehiscens–inversus* zones.

Remarks. The length of the stolons is variable and the shortness of the majority of them is most likely due to breakages as odd specimens from BON 36–39 and SALC 9 show longer arms than normally found.

Derivation of name. *stolonifera*: referring to the side arms.

Genus **Rhabdammina** M. Sars in Carpenter 1869

Rhabdammina linearis Brady, 1879

Fig. 6G–I

Rhabdammina linearis Brady, 1879: 37, pl. 3, figs 10–11.—Brady 1884: 26, pl. 22, figs 1–6.

Description. Test free; large ellipsoidal chamber with two diametrically opposed long, straight, tubular stolons issuing from the narrower ends of the main chamber; aperture a simple opening at the ends of each stolon; wall finely arenaceous, roughly finished.

Measurements (in mm)

		diam. chamber	tube diam.
Figured specimen	NMV P126960	0.32	0.1
Figured specimen	NMV P199405 —Ma 13	0.3	0.1
Unfigured specimen	NMV P199406 —BON 13.5–15	0.16	0.09
Figured specimen	NMV P199407 —BON 13.5–15	0.22	0.07
Unfigured specimen	NMV P199408 —SALC 7	0.26	0.08
Unfigured specimen	NMV P199409 —SALC 7	0.6	0.17

Distribution. SALC 7, Ma 13, BON 13.5–15; *perbonus–inversus* zones.

Remarks. There seems to be nothing to distinguish these early Devonian specimens from Brady's Recent species that cannot be assigned to preservational differences e.g. shorter stolons due to breakages and the slight compression of some specimens. Some specimens do have a more inflated central chamber than the Recent forms.

Rhabdammina proavita n.sp.

Fig. 6F

Description. Test free; small globular prolocular chamber from which two arms issue diametrically; the arms are only slightly narrower than the central chamber, and branch a short distance from the chamber; these secondary stolons are usually narrower than the primary ones; aperture is a simple opening at the ends of the stolons; wall formed of very fine quartz grains, with little cement; surface very smoothly finished.

Holotype. NMV P126961, from Old Taravale Road Cutting, Buchan, sample 7, Taravale Formation.

Measurements (in mm)

		prolocular diam.	primary arm diam.
Holotype	NMV P126961	0.2	0.18
Paratype	NMV P199410—OTRC 7	0.1	0.07

Distribution. Known only from the type locality, OTRC 7; *dehiscens* Zone.

Remarks. In general shape this species is similar to the Recent species, *Rhabdammina cornuta* Brady, but differs in the smooth surface texture and the very fine grains used in the test wall.

R. proavita shows some variation in the size of the central chamber, the length of the primary stolons and the nature of the secondary arms. In some specimens the primary arms may not branch but instead become flaring and flattened, although this may be a preservational artefact in part.

Derivation of name. *provita* (L.): ancestral.

Genus **Saccorhiza** Eimer and Fickert, 1899

Saccorhiza surculus n.sp.

Fig. 6D, E

Description. Test free; a relatively large, flattened proloculum followed by a narrow cylindrical tube of nearly uniform diameter, which bifurcates once; test wall is finely arenaceous with a fairly smooth surface; aperture is a rounded opening at the end of each branch.

Holotype. NMV P126962, from Old Rocky Camp Quarry, Buchan, sample 10–15 m above the Murrindal Limestone, Taravale Formation.

Measurements (in mm)

		length	arm width primary	arm width secondary
Holotype	NMV P126962	0.21	0.02	0.01
Paratype	NMV P199411 —ORCQ	0.25	0.02	0.02

Distribution. Known only from the type locality, ORCQ 10–15; *perbonus* Zone.

Remarks. Hofker (1972) has considered *Saccorhiza* to be a subgenus of *Hyperammina* on the basis of the globular proloculum and the presence of rare abnormal ramifying forms of several otherwise typical *Hyperammina*. Here it is considered that although the two genera are closely related the bifurcation of the test is sufficient to distinguish *Saccorhiza* from *Hyperammina*. The presence or absence of sponge spicules in the test wall is only a specific character.

None of the recovered specimens showed a typical globular proloculum; in all cases this part of the test was flattened and distorted to varying degrees.

Derivation of name. *surculus* (L.): a young shoot or twig; referring to the fancied resemblance of the species.

Genus **Hyperammina** Brady, 1878

Hyperammina reflua n.sp.

Fig. 7C, D

Description. Test free; globular to subglobular proloculum followed by a long tubular second chamber which is narrower than the proloculum and separated from it by a slight constriction; this tubular chamber is turned back on the proloculum initially for about one-third of a whorl and then becomes more or less linear; near the apertural end, the tubular chamber becomes reflexed for about one-quarter of its length; the second chamber is of more or less uniform diameter until near the aperture when it narrows and then widens to a simple circular aperture; wall formed of fine sand grains, with a smoothly finished surface.

Holotype. NMV P126963, from Old Rocky Camp Quarry, Buchan, sample 10–15 paces above the Murrindal Limestone, Taravale Formation.

Measurements (in mm)	proloculum diam.	tube diam.	length
Holotype NMV P126963	0.12	0.07	1.08
Paratype NMV P199412 –ORCQ	0.08	0.18	1.02
Paratype NMV P199413 –BON 36–39	0.14	0.14	1.26

Distribution. ORCQ 10–15, OTRC 5, OTRC 7, BON 36–39; *dehiscens-perbonus* zones.

Remarks. The placement of this and the next species (*H. proboscis* n.sp.) in the genus *Hyperammina* is based on the globular proloculum and the tubular chamber which suggests placement in *Hyperammina* although the early non-rectilinear growth of *reflua* and the reflexed apertural end of the tube in both *reflua* and *proboscis* are characters which have not apparently been reported for *Hyperammina* previously; Hofker (1972, p. 45) stated that 'the tubular part [of *Hyperammina*] is nearly always straight'.

The somewhat contorted growth of *reflua* and *proboscis* is similar to that of the genus *Tolypammina* and *Ammovertella*, but as these are attached genera (see remarks under *Tolypammina*) then the two species (*reflua* and *proboscis*) cannot be placed therein.

The apparently flexible nature of the tubular section in these two species is reminiscent of the genus *Pelosina* but the test shape, proportions of proloculum to tubular section and the wall structure and composition all preclude placement in that genus. The genus *Saccorhiza* often shows irregular growth (Hofker 1972) but that genus also has sponge spicules characteristically in the wall of the test and has a bifurcating tubular chamber, neither of which characters are present in *reflua* or *proboscis*.

Derivation of name. *reflua* (L.): flowing back; referring to the proximal shape of the test.

Hyperammina proboscis n.sp.

Fig. 7A, B

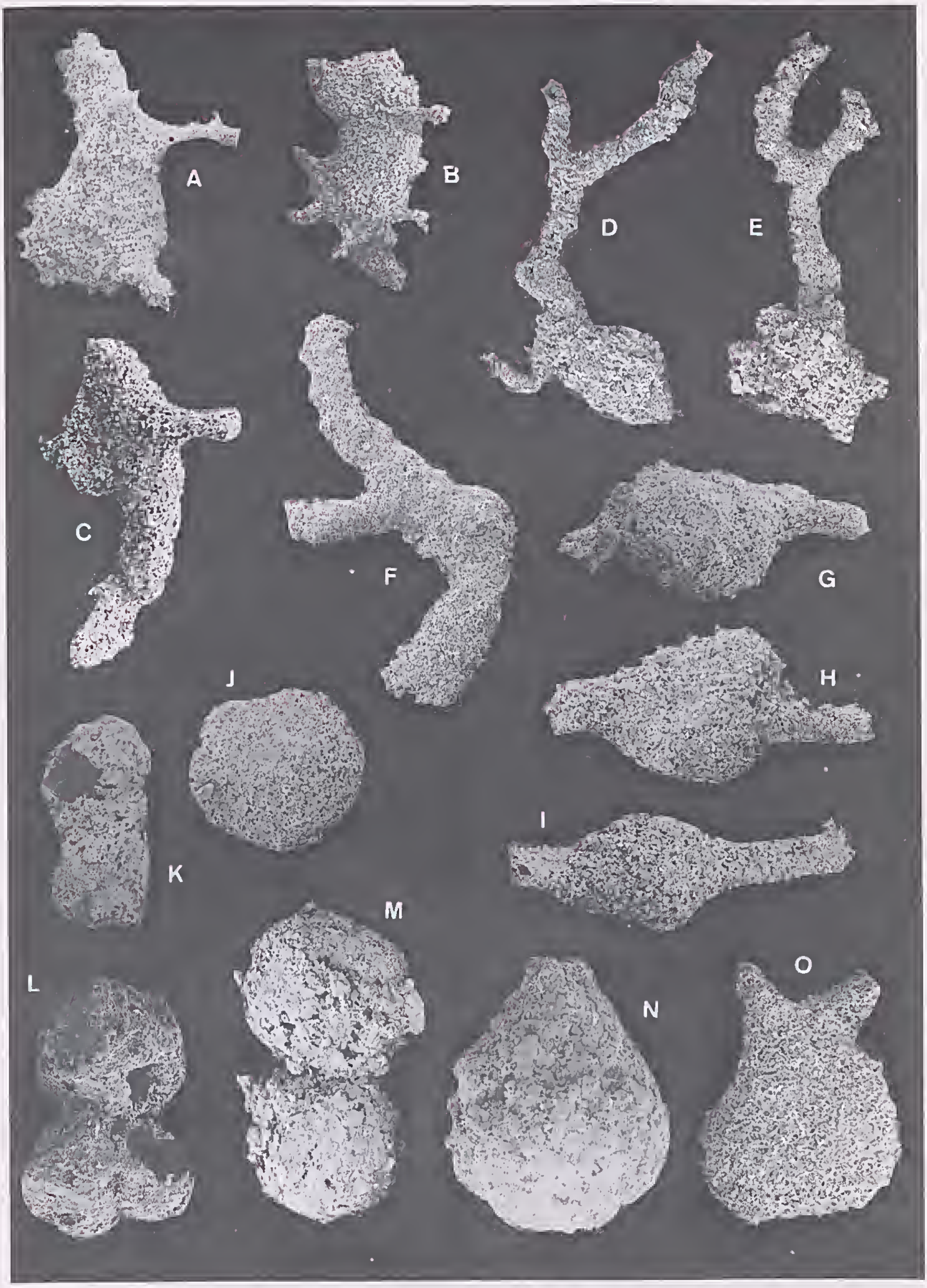
Description. Test free; large; ellipsoidal proloculum, followed by a long second chamber which tapers directly from the proloculum without any constriction at the proloculum; apertural end of the tube reflexed for about one-third of its length; aperture a simple opening at the end of tube; test made of small angular sand grains with little cement, surface roughly finished.

Holotype. NMV P126964, from Gelantipy Road, Buchan, Buchan Caves Limestone, sample Ma 13.

Measurements (in mm)	diam. proloculum	tube diam.	length
Holotype NMV P126964	0.3	0.22	1.0
Paratype NMV P199414–ORCQ	0.16	0.12	0.56
Paratype NMV P199415–Ma 13	0.2	0.13	–

Distribution. Ma 13, ORCQ 10–15; *perbonus-inversus* zones.

Fig. 6. A–C, *Cylindrammina stolonifera* Bell n.sp. A, Paratype, NMV P199402, ×34, SALC 7. B, Holotype, NMV P126994, ×36, SALC 7. C, Paratype, NMV P199404, ×36, SALC 9. D–E, *Saccorhiza surculus* Bell n.sp. D, Holotype, NMV P126962, ×180, ORCQ 10–15. E, Paratype, NMV P199411, ×180, ORCQ 10–15. F, *Rhabdammina proavita* Bell n.sp. holotype, NMV P126961, ×54, OTRC 7. G–I, *Rhabdammina linearis* Brady. G, NMV P199405, ×59, Ma 13. H, NMV P199407, ×90, BON 13.5–15. I, NMV P126960, ×54, SALC 7. J, *Psammosphaera cava* Moreman, NMV P126965, ×200, OTRC 7. K, *Stegnammina cylindrica* Moreman, NMV P126967, ×135, OTRC 2. L–M, *Sorosphaera* sp. cf. *S. confusa* Brady. L, NMV P126966, ×108, OTRC 2. M, NMV P199418, ×180, OTRC 2. N, *Saccammina cumberlandiae* (Conkin), NMV P126982, ×144, BON 36–39. O, *Saccammina biosculata* Moreman, NMV P126968, ×180, ORCQ 10–15.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Remarks. *H. proboscis* differs from *H. reflua* in its ellipsoidal proloculum, no constriction at the base of the tubular chamber and in its rough surface. (See also remarks under *H. reflua.*)

Derivation of name. *proboscis* (L.): elephant trunk.

Hyperammina sp.

Fig. 7E

Description. Test consists of an inflated proloculum, ellipsiodal and slightly elongated followed by a tubular chamber constricted at junction with proloculum; diameter of tube about half that of proloculum; the tube is curved around the proloculum but separated from it; wall of fine particles with very few larger ones imbedded, surface fairly smoothly finished; aperture at end of tube.

Measurements (in mm)
Size: proloculum 0.2×0.14; diam. linear chamber 0.07.

Figured specimen. NMV P126955, Old Taravale Road cutting, Buchan, sample OTRC 7; Taravale Formation.

Distribution. OTRC 7; *perbonus* Zone.

Remarks. This species differs from both *H. reflua* and *H. proboscis* in the shape and size of the proloculum and the immediately recurved tubular chamber. The maximum size to which it may have grown is not known as all of the several specimens found only have a short tubular chamber as shown in Fig. 7E.

Family SACCAMMINIDAE Brady, 1884

Genus Psammosphaera Schulze, 1875

Psammosphaera cava Moreman, 1930

Fig. 6J

Psammosphaera cava Moreman 1930: 48, pl. 6, fig. 12.

Description. Test free; globular, small; test made from larger and smaller grains, but usually only of one type per test, grains in a single layer; surface slightly roughened but that made of the smaller grains smooth; no apparent aperture.

Figured specimen. NMV P126965, from Old Taravale Road cutting, Buchan, sample 7, Taravale Formation.

Measurement
Diameter 0.11 mm.

Distribution. OTRC 2, OTRC 7; *inversus–serotinus* zones.

Remarks. Specimens are smaller than those of Moreman but size does not seem to be an adequate specific differentiator for such a simple organism.

Genus Sorosphaera Brady, 1879

Sorosphaera sp. cf. S. confusa Brady, 1879

Fig. 6L, M

Description. Test globular to subglobular, with commonly one flattened side indicating a former attachment surface; test formed of very fine grains, well cemented and with the test wall smoothly finished inside and out; no apparent aperture.

Figured specimen. NMV P126966, from Old Taravale Road cutting, Buchan, sample 2, Taravale Formation.

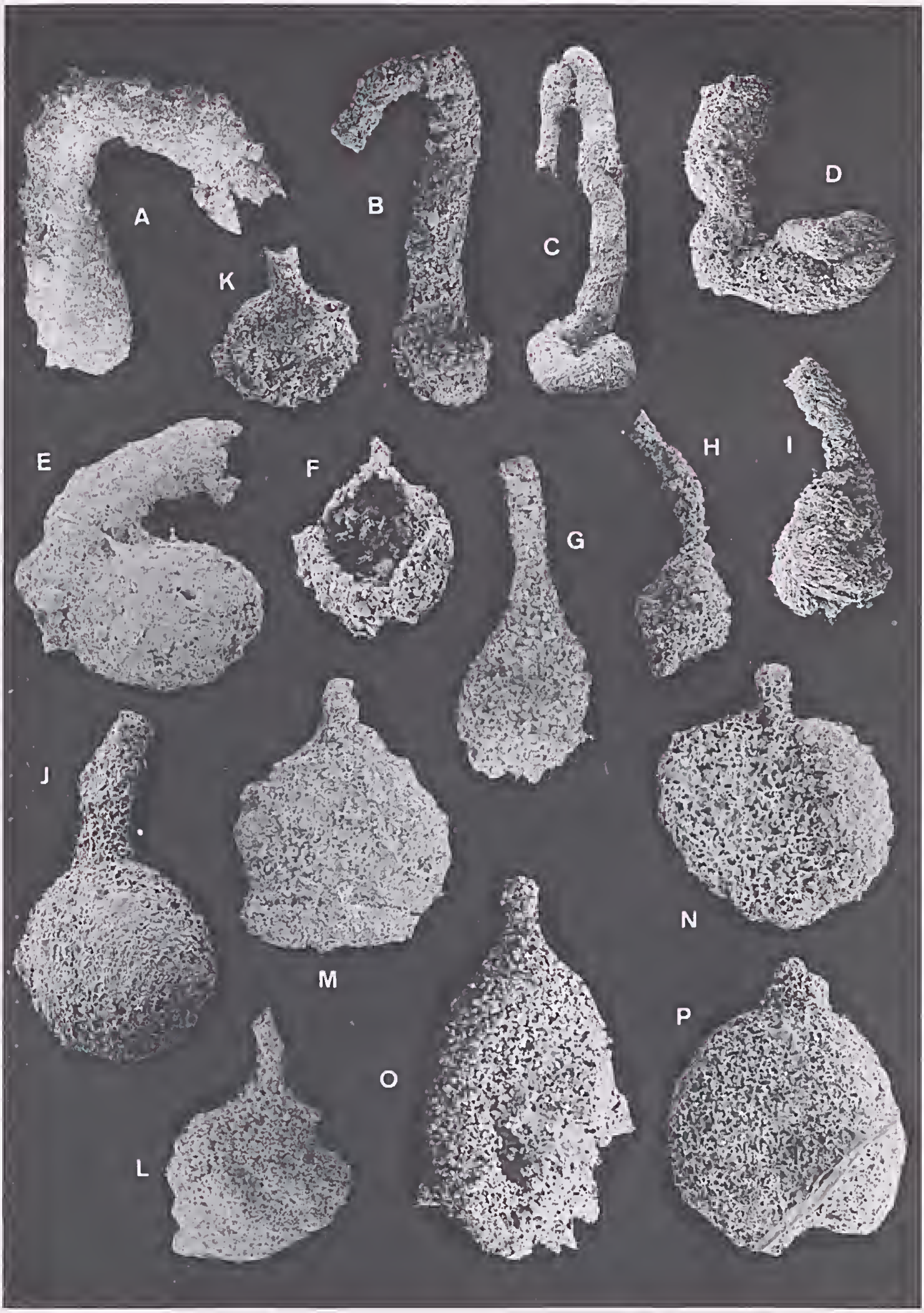
Measurements (in mm)

Figured specimen	NMV P126966	
	diam. chamber 1:	0.13
	chamber 2:	0.12
Unfigured specimen	NMV P199416–OTRC 2:	0.14
Unfigured specimen	NMV P199417–OTRC 7:	0.16
Figured specimen	NMV P199418–OTRC 2	
	chamber 1:	0.11
	chamber 2:	0.12

Distribution. OTRC 2, OTRC 5, OTRC 7; *inversus–serotinus* zones.

Remarks. The determination of species within *Sorosphaera* is difficult. The number of chambers

Fig. 7. A–B, *Hyperammina proboscis* Bell n.sp. A, Paratype, NMV P199414, ×90, ORCQ 10–15. B, Holotype, NMV P126964, ×45, Ma 13. C–D, *Hyperammina reflua* Bell n.sp., holotype, NMV P126963, ×54, ORCQ 10–15. D, Paratype, NMV P199412, ×54, ORCQ 10–15. E, *Hyperammina* sp., NMV P126955, ×144, OTRC 7. F, *Lagenammina stilla* Moreman, NMV P126970, ×90, Ma 13. G–I, *Lagenammina talenti* Bell n.sp. G, Holotype, NMV P126971, ×90, SALC 7. H, Paratype, NMV P199419, ×54, SALC 7. I, Paratype, NMV P199420, ×63, ORCQ 10–15. J, L, *Lagenammina sphaerica* Moreman. J, NMV P126975, ×72, ORCQ 10–15. L, NMV P126969, ×59, Ma 13. K, M–N, *Lagenammina laxacolla* Bell n.sp. K, Holotype, NMV P126972, ×45, Ma 13. M, Paratype, NMV P199423, ×72, SALC 7. N, Paratype, NMV P199422, ×117, SALC 9. O–P, *Lagenammina ovata* Bell n.sp. O, Holotype, NMV P126973, ×54, SALC 9. P, Paratype, NMV P199426, ×90, ORCQ 10–15.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joined together has, in the past, been a character used to distinguish separate species (Dunn 1942; McClellan 1966) even though McClellan (1966) considered that it was highly likely that several species were only various chamber combinations of the one species. Single chambers only were quite common and rare double chamber forms occurred with one three chambered fragment recovered. These are considered to be aspects of the one species. In multichambered forms each test was complete i.e. there was a double wall between the adjacent chambers with no apparent openings between the chambers. The chambers are apparently not tightly attached together and the flattened side represented the adpressed surface. There was no apparent aperture; the various openings in the test wall were most likely due to dissolution effects during the acid treatment.

Single chambered specimens of *Sorosphaera* are distinguished from *Psammosphaera* in having a much thinner test wall and, in the studied specimens, in having one or more flattened surfaces.

Sorosphaera confusa has a many chambered agglomerated form (Brady 1879). No such shape was found in this study, but as the individual chambers show no apparent differences to those of *confusa*, the present material is placed in comparison with it.

Genus Stegnammina Morman, 1930

Stegnammina cylindrica Moreman, 1930

Fig. 6K

Stegnammina cylindrica Moreman 1930: 49, pl. 7, fig. 12.

Description. Test apparently free; cylindrical, ends slightly rounded; fine grained test with a smooth inner surface and a slightly roughened outside; no apparent aperture.

Figured specimen. NMV P126967, from Old Taravale Road cutting, Buchan, sample 2, Taravale Formation.

Distribution. OTRC 2; *serotinus* Zone.

Remarks. Some rarer specimens show an almost triangular cross-section rather than the round section of the commoner form; they are thus similar to *S. triangularis* Moreman but are not here considered as a separate species as the shape difference may be a deformation due to preservation.

Genus Saccammina Carpenter, 1869

Saccammina biosculata Moreman, 1933

Fig. 6O

Saccammina biosculata Moreman 1933: 395, pl. 47, fig. 6.

Description. test free; small; main chamber flattened but originally probably spherical; neck short, squat; wall thin, composed of fine sand grains with little cement, surface roughly finished; the neck is divided into two smaller necks for most of its length, these being almost perpendicular to each other; a simple aperture at the end of each neck.

Figured specimen. NMV P126968, from Old Rocky Camp Quarry, Buchan, sample ORCQ 10–15, Buchan Caves Limestone.

Measurements (in mm)

Figured specimen	NMV P126968	length: 0.17 width: 0.12

Distribution. ORCQ 10–15; *perbonus* Zone.

Remarks. Only one specimen was found but, although slightly smaller than Moreman's figured type, it does not differ in any other aspect. Moreman's specimen came from Middle Silurian sediments.

Saccammina cumberlandiae (Conkin, 1961)

Fig. 6N

Proteonina cumberlandiae Conkin 1961: 248–250, pl. 14, figs 1–3; pl. 26, figs 4–5; text-figs 2–3. — Conkin et al. 1963: 222, pl. 1, figs 12–14. — Conkin & Conkin 1964a: 32, pl. 2, figs 38–41.

Description. Test free, consisting of one inflated, slightly tapering chamber with a short, wide, tapering neck; aperture circular at end of neck; wall composed of medium-sized quartz grains fairly smoothly finished.

Figured specimen. NMV P126982, from Bonanza Gully, Bindi, sample BON 36–39, Buchan Caves Limestone.

Measurements (in mm)
Length 0.28; max. diam. 0.23; chamber length 0.23; neck length 0.05; neck max. diam. 0.11; neck min. diam. 0.05; length/width 1.23.

Distribution. From BON 36–39 only; *perbonus* Zone.

Remarks. Only rare specimens of this form were recovered. They compare closely with the description of *S. cumberlandiae* from the Lower Carboniferous (Lower Mississippian) of the U.S.A, although being somewhat more rounded (l/w = 1.23) but this ratio is quite variable (Conkin et al. 1963; Conkin & Conkin 1964a; range 1.19–1.94).

Genus **Lagenammina** Rhumbler, 1911

Lagenammina sphaerica Moreman, 1930

Fig. 7J, L

Lagenammina sphaerica Moreman 1930: 51, pl. 5, fig. 15.

Description. Test free; a globular chamber with a long, narrow neck; aperture a simple opening at the end of the neck; test formed of fine grains with a fairly smoothly finished surface.

Figured specimens. NMV P126969, from Ma 13, Gelantipy Road, Buchan; Taravale Formation.
NMV P126975, from from Old Rocky Camp Quarry, Buchan, sample ORCQ 10–15 m above the Murrindal Limestone, Taravale Formation; cast.

Measurements (in mm)

Figured specimen	NMV P126969	length: 0.16
		width: 0.44
		aperture: 0.06

Distribution. Ma 13, SALC 7, SALC 9, BON 13.5–15; *perbonus–inversus* zones.

Remarks. Due to compression during preservation most specimens were somewhat flattened but the degree of distortion was quite variable even within the one sample. Specimens from ORCQ 10–15 were preserved as casts and show the spherical shape without compression. The neck was often slightly curved, and its diameter varied between localities but, until more and better preserved specimens are found, these are not considered to be of sufficient importance to differentiate species.

Lagenammina stilla Moreman, 1930

Fig. 7F

Lagenammina stilla Morman 1930: 51, pl. 6, fig. 6.

Description. Test free; small; a globular chamber with a very short neck, about one-sixth the length of the globular test; thin walled, about two grains thick; test formed of a mixture of large and small sand grains, surface rough; aperture circular at end of short neck.

Figured specimen. NMV P126970, from Ma 13, Gelantipy Road, Buchan; Taravale Formation.

Measurements (in mm)

Figured specimen	NMV P126970	length: 0.3
		width: 0.24
		aperture: 0.04

Distribution. Ma 13; *inversus* Zone.

Remarks. The test is made of a random placement of small and larger sand grains apparently with little cement, giving the test a rough external surface. The interior of the test is smooth suggesting that originally there was an inner organic layer on which the grains were laid.

Lagenammina talenti n.sp.

Fig. 7G–I

Description. Test free; small; ellipsoidal body chamber followed by a long, wide, slightly curving neck; test wall formed of largish grains, surface rough; aperture circular at end of neck.

Holotype. NMV P126971, from south arm, Limestone Creek, Bindi, sample 7, Taravale formation.

Measurements (in mm)	length	width	aperture
Holotype NMV P126971	0.5	0.2	0.05
Paratype NMV P199419–SALC 7	0.8	0.26	0.06
Paratype NMV P199420–ORCQ	0.48	0.26	0.09
Paratype NMV P199421–Ma 13	0.51	0.27	0.07

Distribution. SALC 7, Ma 13, ORCQ 10–15; *perbonus–inversus* zones.

Remarks. The body chamber is usually compressed. The long neck shows different degrees of curvature which suggests that it may have been flexible when living. The overall shape of this species clearly separates it from other *Lagenammina*. *L. silnica* Malic 1992 has a similar body chamber shape but is a much smaller species and lacks the long, produced neck of *L. talenti.*

Derivation of name. For Professor J. A. Talent, Macquarie University, for his contributions to the biostratigraphy of the Devonian in Australia.

Lagenammina laxacolla n.sp.

Figs 7K, M, N; 8A

Description. Test free; small; a discoidal chamber with a short, straight, wide neck; test formed of fine grains, smoothly finished; aperture circular at end of neck.

Holotype. NMV P126972, from Gelantipy Road, Buchan, sample Ma 13, Buchan Caves Limestone.

Measurements (in mm)	length	width	aperture
Holotype NMV P126972	0.5	0.48	0.1
Paratype NMV P199422–SALC 9	0.32	0.28	0.05
Paratype NMV P199423–SALC 7	0.53	0.42	0.06
Paratype NMV P199424–Ma 13	0.48	0.32	0.06
Paratype NMV P199425 –BON 36–39	0.48	0.26	0.07

Distribution. Ma 13, SALC 7, SALC 9, BON 36–39; *perbonus-inversus* zones.

Remarks. This small species differs from *L. stilla* in having a short, wide neck.

Some specimens from Bonanza Gully and Gelantipy Road differ in having an aboral spine present (Fig. 8A). Whether this is a sufficient character for specific difference must await better preserved specimens.

Derivation of name. *laxus* (L.): wide; *collum* (L.): neck.

Lagenammina ovata n.sp.

Fig. 7O, P

Description. Test free; large ovate body chamber, with a short, narrow neck; test made of small uniform grains with little cement, surface slightly rough; aperture circular at end of neck.

Holotype. NMV P126973, from south arm, Limestone Creek, Bindi, sample 9, Taravale Formation.

Measurements (in mm)	length	width	aperture
Holotype NMV P126973	0.74	0.38	0.06
Paratype NMV P199426–ORCQ	0.48	0.36	0.07

Distribution. SALC 9, ORCQ 10–15; *perbonus-inversus* zones.

Remarks. *L. ovata* differs from the other species of *Lagenammina* in its large ovate body chamber and short narrow neck. It seems closest to *L. talenti* from which it differs in body/neck proportions and in the smoother test surface.

Derivation of name. *ovata* (L.): oval-shaped.

Genus **Stomasphaera** Mound, 1961 *emend.* Bell (in Simpson et al. 1993)

Stomasphaera cyclops n.sp.

Fig. 9A–D

Description. Test free; subglobular to ovate chambers joined to form a linear to arcuate series; chamber size variable but not necessarily increasing in size along the series; test wall coarsely agglutinate with a smooth to rough surface; aperture rounded to elongate, may be depressed slightly and is surrounded by an area of finer grains.

Holotype. NMV P126977, from Bonanza Gully, Bindi, sample 220–240. Buchan Caves Limestone.

Measurements (in mm) (largest chamber only measured)	length	width	aperture
Holotype NMV P126977	0.35	0.23	0.09×0.06
Paratype NMV P199432 –BON 220–240	0.4	–	0.08
Paratype NMV P199433 –BON 220–240	0.4	–	0.12

Distribution. Known from the type locality only, BON 220–240; *perbonus* Zone.

Remarks. *S. cyclops* differs from the Victorian Upper Silurian form *S. globosa* Bell (*in* Simpson et al. 1993) in having a larger aperture, in the chamber shape being not as globular but more elongate and in the wide band of finer grains about the aperture. The aperture remains open in earlier chambers. There is apparently no connection between successive chambers. Both single and multithalamous tests were present.

The genus *Stomasphaera* differs from *Saccamminoides* Geroch, 1955 which shows a sharp change in direction of coiling after the first 2–3 chambers (Loeblich & Tappan 1988). This coiling character has been not seen in any specimens of *cyclops* or *globosa*.

Derivation of name. *cyclops* (L.): a race of one-eyed giants; referring to the large aperture.

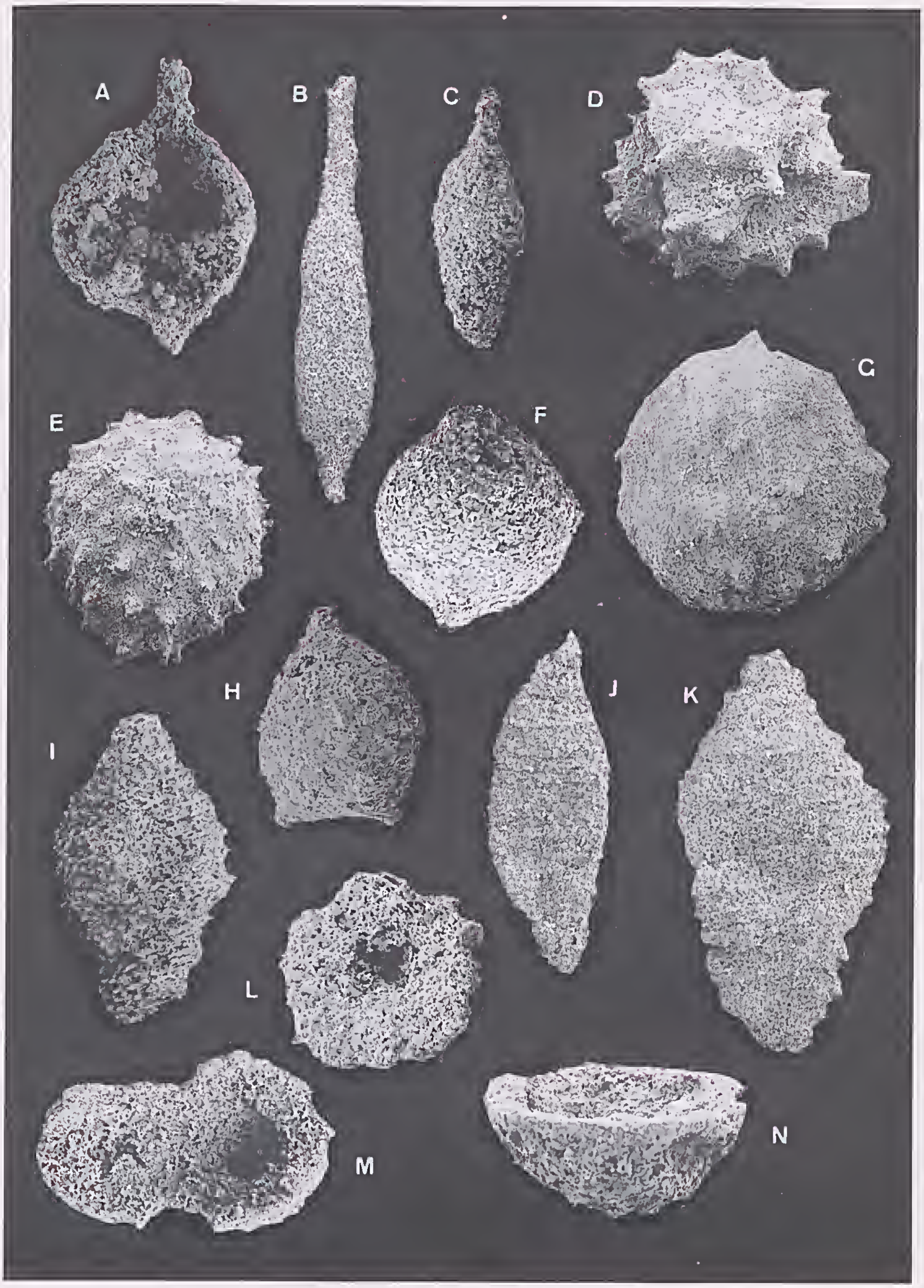
Genus **Ordovicina** Eisenack, 1937

Ordovicina eisenacki (Conkin & Conkin, 1964)

Fig. 8I–K

Amphitremoida eisenacki Conkin & Conkin 1964b: 73, pl. 12, figs 8–10.

Fig. 8. A, *Lagenammina laxacolla* Bell n.sp., paratype, NMV P199424, ×90, Ma 13, note abapertural spine. B–C, *Pelosina grandaeva* Bell n.sp. B, Holotype, NMV P126976, ×135, ORCQ 10–15. C, Paratype, NMV P126999, ×59, Ma 13. D-E, *Thurammina echinata* Dunn. E, NMV P126978, ×72, BON 36–39. D, NMV P, ×90, OTRC 7. F, *Thurammina foesteri* Dunn, NMV P126981, ×72, ORCQ 10–15. G, *Thurammina subsphaerica* Moreman, NMV P126979, ×72, BON 13.5–15. H, *Thurammina tributa* Dunn, NMV P126980, ×108, BON 39–44. I–K, *Ordovicina eisenacki* (Conkin & Conkin). I, NMV P127000, ×72, BON 36–39. J, NMV P127001, ×126, BON 13.5–15. K, NMV P199434, ×135, ORCQ 10–15. L–M, *Patellammina prona* Bell n.sp. L, Holotype, NMV P126985, ×54, BON 220–240. M, Paratype, NMV P126998, ×63, BON 220–240. N, *Hemisphaerammina* sp., NMV P199599, ×126, OTRC 7.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Description. Test free; a single fusiform chamber with a small aperture at each end; the apertural ends slightly produced; test composed of fine sand grains, slightly roughly finished; the surface of the test shows transverse low ridges.

Measurements (in mm)	length	width	apertures	
Figured specimens			S_1	S_2
NMV P199434–ORCQ	0.36	0.2	0.03	0.02
NMV P127001–BON 13.5–15	0.36	0.12	0.03	broken
NMV P127000–BON 36–39	0.6	0.35	0.09	0.05

Distribution. BON 13.5–15, BON 36–39, ORCQ 10–15; *perbonus* Zone.

Remarks. The specimens recovered were larger than those described by Conkin & Conkin (1964b) but appear otherwise to be the same species. All specimens were compressed and the surface transverse ridges may be an artefact of the preservation. The apertural ends were deformed and the measurements given are lower values only.

The present specimens differ from the larger form recorded by Conkin & Conkin (1964b) as *Amphitremoida* sp. in lacking the 'collar' surrounding the apertures, and from *A. hauffmani* (Conkin & Conkin 1964b) in their much larger size and different length/width ratios. *O. kielcensis* (Malec 1992) described from the upper Emsian beds of the Gory Swietokrzyskie Mountains of Poland is similar to *O. eisenacki* but appears from the data given to be more slender; however the varying amounts of compaction (flattening) of specimens could easily account for the small differences between these two species.

Genus **Pelosina** Brady, 1879

Pelosina grandaeva, n.sp.

Fig. 8B, C

Description. Test free; a single fusiform chamber, about three times as long as wide, with long tubular extensions at either end; fine grained test wall but not smoothly finished; simple circular aperture at ends of the tubular extensions.

Holotype. NMV P126976, from Old Rocky Camp Quarry, Buchan, sample ORCQ 10–15, Taravale Formation.

Measurements (in mm)	length	width	aperture	
			S_1	S_2
Holotype NMV P126976	0.38	0.06	0.02	0.02
Paratype NMV P126999 –Ma 13	0.64	0.22	0.05	broken

Distribution. ORCQ 10–15, Ma 13; *perbonus–inversus* zones.

Remarks. The tubular extensions were of unequal length in the type specimen but this is due likely to breakages during preservation as other specimens were of more equal length. The produced ends appear to have been flexible since they are slightly curved.

Pelosina was previously known to range from the Cretaceous to Recent (Loeblich & Tappan 1988).

Derivation of name. *grandaeva* (L.): very old.

Genus **Thurammina** Brady, 1879

Thurammina echinata Dunn, 1942

Fig. 8D, E

Thurammina echinata Dunn 1942: 331, pl. 42, figs 20, 21, 23.

Description. Test free; globular, with many short, pointed papillae on the surface; papillae are hollow with a simple opening at the end of each; test composed of very fine sand grains, smoothly finished.

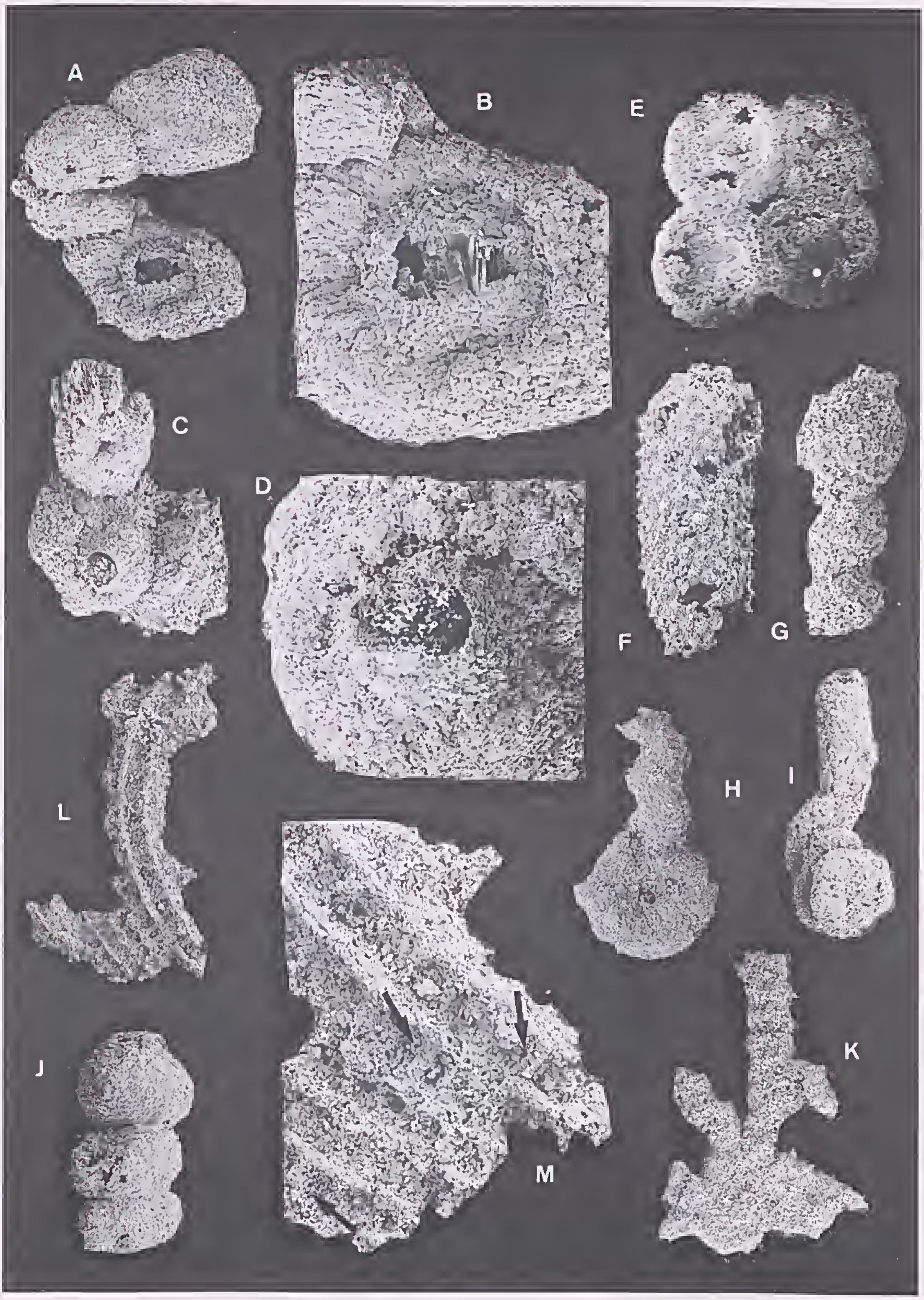
Figured specimen. NMV P126978, Bonanza Gully, Bindi, sample 36–39, Buchan Caves Limestone.

Measurement (in mm)
Figured specimen NMV P126978 diameter: 0.48

Distribution. ORCQ 10–15, BON 36–39, OTRC 5, OTRC 7; *dehiscens–perbonus* zones.

Remarks. A widespread and common species. The test is thin and often distorted or compressed but without showing any signs of breakages

Fig. 9. A–D, *Stomasphaera cyclops* Bell n.sp. A, Holotype, NMV P126977, ×72, BON 220–240. B, Close-up of aperture of holotype, ×180. C, Paratype, NMV P199432, ×54, BON 220–240. D, Close-up of aperture of paratype, ×180. E, *Metamorphina tholus* (Moreman), NMV P126984, ×72, BON 13.5–15. F, *Thurammina zaramama* Bell n.sp., holotype, NMV P126974, ×72, Ma 13. G, *Reophax troca* Bell n.sp., holotype, NMV P126993, ×126, OTRC 7. H, *Lituotuba torquata* Bell n.sp., holotype, NMV P126990, ×126, OTRC 7. I, *Lituotuba helix* Bell n.sp., holotype, NMV P126991, ×72, OTRC 5. J, *Hormosina divitiae* Bell n.sp., holotype, NMV P126992, ×72, BON 220–240. K–M, *Kerionammina prolata* Bell n.sp. K, Holotype, NMV P126986, ×117, ORCQ 10–15. L, Paratype, NMV P199597, ×180, ORCQ 10–15, showing internal longitudinal walls. M, Close-up of paratype, arrows indicating transverse partitions between longitudinal walls, ×540.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indicating that the test may have been flexible when the animal was alive.

Thurammina subsphaerica Moreman, 1930

Fig. 8G

Thurammina subsphaerica Moreman 1930: 52, pl. 5, fig. 16.

Description. Test free; globular; a small number (about 20) of short papillae more or less evenly distributed over the surface; test with a thin wall of very fine grains with little cement, surface smooth; simple circular aperture at the end of each papilla.

Figured specimen. NMV P126979, from Bonanza Gully, Bindi, sample 13.5–15, Buchan Caves Limestone.

Measurement (in mm)
Figured specimen NMV P126979 diameter: 0.53

Distribution. BON 13.5–15, OTRC 5, OTRC 7, ORCQ 10–15; *dehiscens–perbonus* zones.

Remarks. *T. subsphaerica* differs from *T. echinata* in the fewer but broader and less pointed papillae. As with *echinata*, *subsphaerica* was possibly flexible when alive.

Thurammina tributa Dunn, 1942

Fig. 8H

Thurammina tributa Dunn 1942: 334, pl. 43, fig. 20 (as *T. trituba*).

Description. Test free; small; globular to ellipsoidal; three papillae, short, wide, more or less evenly positioned on the equatorial plane of the globular chamber; test formed of medium sized sand grains with little cement; aperture a simple opening at the end of each papillae.

Figured specimen. NMV P126980, from Bonanza Gully, Bindi, sample 39–44, Buchan Caves Limestone.

Measurements (in mm)
Figured specimen NMV P126980
maximum diameter: 0.28; minimum diameter: 0.21

Distribution. BON 39–44, BON 56–60.5; *perbonus* Zone.

Remarks. The three short, evenly placed papillae make this species easily identifable.

Thurammina foerstei Dunn, 1942

Fig. 8F

Thurammina foerstei Dunn 1942: 331, pl. 43, fig. 27.

Description. Test free; globular, with two low, dome-shaped papillae almost diametrically opposed; test made from even sized, very small grains, smoothly finished; aperture a simple opening at the summit of each papilla.

Figured specimen. NMV P126981, from from Old Rocky Camp Quarry, Buchan, sample ORCQ 10–15.

Measurement (in mm)
Figured specimen NMV P126981 diameter: 0.39

Distribution. ORCQ 10–15; *perbonus* Zone.

Remarks. My specimens are larger than Dunn's original (0.75 mm diameter against 0.29 mm), but otherwise there are no apparent differences.

Thurammina zaramama, n.sp.

Fig. 9F

Description. Test free; ellipsoidal chamber, covered with many (± 100) small, short papillae arranged in rows; test wall thin, very finely agglutinated; interior surface smooth; aperture a small opening at the top of most papillae; specimens were usually red-brown.

Holotype. NMV P126974, from Gelantipy Road, Buchan, sample Ma 13, Buchan Caves Limestone.

Measurements (in mm)
Holotype NMV P126974 length: 0.6; width: 0.23.

Distribution. Ma 13; BON 60.5–65; *perbonus–inversus* zones.

Remarks. The shape of the test and the large number of papillae are sufficient to distinguish this species from any other *Thurammina*. The shape of the chamber varied with the locality; those from Gelantipy Road had a long ellipsoidal form whilst those from Bonanza Gully were more rounded. Whether this is a reflection of the differing sedimentary facies or an age difference must await more specimens from other localities.

Derivation of name. *zaramama* (?Quechua, Peruvian native): for the similarity to the stone imitation maize heads of the Andean Indians (Whymper 1892).

Genus **Webbinelloidea** Stewart and Lampe, 1947

Webbinelloidea crassus, n.sp.

Fig. 10J, K

Description. Test attached; in the form of a low dome with a circular attachment area; test made of coarse grains, wall thick, but variable depending on the size of the grains used, surface rough; internal surface smooth; no apparent aperture.

Holotype. NMV P126983; from Bonanza Gully, Bindi, sample 206, Buchan Caves Limestone.

Measurements (in mm)
maximum diameter: 0.325; aperture diameter: 0.1

Distribution. BON 206, BON 220–240; *perbonus* Zone.

Remarks. This a very robust *Webbinelloidea*, formed from very coarse sand grains. Only single-chambered forms were recovered although *Webbinelloidea* may show multichambered tests (Stewart & Lampe 1947).

Genus **Metamorphina** Browne, 1963

Metamorphina tholus (Moreman, 1933)

Fig. 9E

Webbinella tholus Moreman 1933: 395, pl. 47, figs 8, 10.
Metamorphina tholus—McClellan 1966: 489, pl. 37, figs 15–19; pl. 41, figs 15–19.

Description. Test probably formerly attached; a low dome, sometimes showing a marginal flange; monothalamous but individual chambers may aggregate into pseudomultilocular tests; sutures between chambers straight; wall of fine grains, smooth surface; no apparent aperture.

Figured specimen. NMV P126984, from Bonanza Gully, Bindi, sample 13.5–15, Buchan Caves Limestone.

Measurement (in mm)
Figured specimen NMV P126984
chamber diameter: 0.22

Distribution. BON 13.5–15; *perbonus* Zone.

Remarks. The low-domed test and the absence of a basal wall serve to place the specimens in the genus *Metamorphina*. McClellan (1966) has given a full discussion of the criteria for distinguishing *Metamorphina* Browne 1963, *Webbinelloidea* Stewart & Lampe 1947 and *Hemisphaerammina* Loeblich & Tappan 1957.

Although the figure shows a four-chambered specimen, single and double chambered forms were more common.

Genus **Hemisphaerammina** Loeblich & Tappan, 1957

Hemisphaerammina sp.

Fig. 8N

Description. Test hemispherical, with a thick wall; attachment surface flat, smooth with no flanges and no evidence of a basal membrane; wall coarse and roughly finished.

Figured specimen. NMV P; Old Taravale Road cutting, Buchan, sample 7, Taravale Formation.

Distribution. OTRC 7; *perbonus* Zone.

Remarks. Only rare specimens were recovered. It should be noted that the possibility exists that some specimens placed within the genus *Hemisphaerammina* may not belong within the Foraminiferida but represent egg-capsules of different species of gastropods (Adegoke et al. 1969; Bell & Burn 1979).

Genus **Patellammina** n.gen.

Genotype. *Patellammina prona* n.sp.; NMV P126985, from Bonanza Gully, Bindi, sample BON 220–240, Buchan Caves Limestone.

Description. Test apparently free; multilocular, upto three chambers joined in an irregular series; chambers are flattened, disc-like, with a floor; in section the chambers are meniscus-shaped; aperture an irregular hole, usually subcircular, in the concave (?basal) face; test coarsely agglutinated, with a rough surface.

Remarks. This genus belongs in the Hemisphaerammininae as it has obvious affinities with *Hemisphaerammina, Webbinelloidea, Colonammina* and *Ammopemphix*. *Patellammina* n.gen. differs from *Hemisphaerammina* and *Webbinelloidea* in being very flattened and not hemispherical, and from *Hemisphaerammina* and *Colonammina* in the occurrence of not only single chambered but multiple chambered tests; *Colonammina* and *Ammopemphix* have the aperture on the upper, convex surface. It differs from the Recent genus *Causia* Rhumbler which has a chitinous test with only a few attached sand grains and which also possesses a peripheral flange.

It is considered that *Patellammina* n.gen. was free living as no attached specimens have been found nor is there any evidence of attachment scars on any specimens.

Derivation of name. *patella* (L.): dish, saucer-shaped.

Patellammina prona n.sp.

Fig. 8L, M

Description. As for the genus *Patellammina*.

Holotype. NMV P126985, from Bonanza Gully, Bindi, sample 220–240, Buchan Caves Limestone.

Measurements (in mm)			chamber diam.	aperture
Holotype	NMV P126985		0.6	0.07
Paratype	NMV P126998			
	–BON 220–240	chamber 1:	0.34	0.17
		chamber 2:	0.34	0.1
Paratype	NMV P126997			
	–BON 220–240		0.31	0.1
Paratype	NMV P126996–Ma 13		0.31	0.09

Distribution. BON 220–240, Ma 13; *perbonus–inversus* zones.

Remarks. As for the genus.

Derivation of name. *prona* (L.): flatlying.

Genus Kerionammina Moreman, 1933

Kerionammina prolata n.sp.

Fig. 9K–M

Description. Test attached; flattened and spreading in a digitate manner, with once bifurcating arms; early chambers indistinct; wall thin, finely arenaceous—on the upper, unattached side with a roughened surface with transverse ridges, and the attached surface smooth, often translucent to transparent; interior divided into chamberlets which run out to the tips of the arms, the wall between the chamberlets is thin and smooth; aperture not observed.

Holotype. NMV P126986, from Old Rocky Camp Quarry, Buchan, sample 10–15, Taravale Formation.

Measurements (in mm)	basal width		width	length
Holotype NMV P126986	0.35	arm 1:	0.05	0.2
		arm 2:	0.04	0.1
		arm 3:	0.04	–

Paratype NMV P199597
distance between longitudinal partitions: 0.008–0.012
distance between transverse internal partitions: 0.006–0.01

Distribution. ORCQ 10–15, OTRC 7; *perbonus–inversus* zones.

Remarks. The test shows no obvious places of attachment but the varying shapes of the specimens indicate that they were supported during growth and conformed to the shape of the supporting body.

The interior chamberlets, in wider specimens, are arranged in parallel rows but, in narrow specimens and in the narrower arms, the chamberlets are often irregularly placed. Moreman (1933) erected the genus for specimens from the Middle Ordovician.

Kerionammina prolata n.sp., differs from *K. favus* Moreman in having a more regular, digitate spreading pattern, in being finely arenaceous and in having no apparent apertures.

The Recent genus *Jullienella* Schlumberger has some features similar to *Kerionammina* (rigid agglutinated walls, flabelliform shape, digitate growth, interior with weak to strong transverse ridges). However Norvang (1961) did not consider *Jullienella* to possess even rudimentary chamberlets as the internal partitions are short and widely scattered, although Buchanan (1960) stated that the internal space was divided into 'intercommunicating canals by longitudinal partitions of cemented sand grains' and Hayward & Gordon (1984) in describing a new species of *Jullienella* from New Zealand stated that the interior surface of the walls was weakly wrinkled. The possibility exists that *Kerionammina* in the Palaeozoic is the ancestor of the Recent *Jullienella* by a change in the form of the interlaminary space but the material available at present does not permit further discussion of this point.

Conkin & Conkin (1982) assigned *K. favus* to Incertae sedis without giving any reasons.

Derivation of name. *prolata* (L.): extended.

Family AMMODISCIDAE Reuss, 1862

Subfamily Tolypammininae Cushman, 1928

The identification of the vermiform Lower Palaeozoic foraminiferal genera has caused much confusion and discussion in the literature. In particular the separation of the genera *Tolypammina* Rhumbler 1895 and *Ammovertella* Cushman 1928 has given rise to much discussion and varying interpretations of these genera (Barnard 1958; Bermudez & Rivero 1963; Conkin 1961; Conkin & Conkin 1964b; Gutschick & Treckman 1959; Henbest 1963; Hofker 1972; Ireland 1956).

In an attempt to distinguish these two genera Ireland (1956) proposed that the main distinguishing features were the tube cross-section, coiling or bending in the initial growth stage and the presence or absence of an agglutinate floor to the tubular section wherever it was attached. However he included in his description of the species within each genus forms with and without these characteristic features. Gutschick & Treckman (1959) in their study of Lower Carboniferous foraminiferans followed Ireland but found

(p. 241) '... some tolypamminids contradict some of Ireland's criteria for distinguishing between *Tolypammina* and *Ammovertella*'.

Barnard (1958) proposed a simple division of the genera: *Tolypammina* having no initial coiling about the proloculum, and *Ammovertella* with a planispiral initial coiling of the tubular section about the proloculum. He also pointed out that 'In both *Tolypammina* and *Ammovertella* the final tubular portion of the test is similar and without study of the initial part it is impossible to separate the genera' (Barnard 1958: 117).

Conkin (1961) proposed a separation of the genera based on the second chamber; his criteria are similar to those of Ireland.

A third genus of Palaeozoic tolypamminid, *Minammodytes*, was introduced by Henbest (1963), which differed from *Tolypammina* in having the second chamber partly enclosing the proloculum and from *Ammovertella* in not having the second chamber growing in a zigzag manner. However this latter difference would seem to be, at most, only a specific distinguishing character.

Henbest (1963) considered *Minammodytes* to be an early Carboniferous genus, while Conkin & Conkin (1982), in a review of the Palaeozoic North American foraminiferans, placed the first appearance of *Ammovertella* as Lower Carboniferous and of *Tolypammina* as Middle Ordovician, but made no mention of *Minammodytes*.

As the degree of attachment of the second chamber and so the presence or absence of a 'floor' are both greatly variable within specimens that otherwise appear identical and the degree of diagenesis of the sediments causes varying amounts of distortion of the tests, the simplest criterion for separating *Tolypammina* and *Ammovertella* is that proposed by Barnard (1958) and is followed here. *Minammodytes* is considered a junior synonym of *Serpulopsis* Girty 1911 (Loeblich & Tappan 1988).

The Upper Carboniferous *Ammodiscella* Ireland 1956 and the Recent *Hemidiscella* Bock 1968 both differ from *Tolypammina* and *Ammovertella* in having a symmetrical planispirally enrolled second chamber before the coiling becomes irregular.

Genus **Tolypammina** Rhumbler, 1895

Tolypammina anguinea n.sp.

Fig. 10A, B

Tolypammina sp.—Bell in Simpson et al. 1993: 146, figs 3L, M.

Description. Test originally attached; subspherical proloculum followed by a long hemitubular second chamber which usually winds about in a highly irregular manner; wall formed of fine grains, surface fairly rough; aperture circular at the end of the second chamber; attached side of test shows no evidence of a floor of attachment but the edges of the tube may be slightly flared.

Holotype. NMV P126988, from ORCQ 10–15, Old Rocky Camp Quarry, Buchan, Buchan Caves Limestone.

Measurements (in mm)	proloculum diam.	aperture
Holotype NMV P126988	0.02	0.03
Paratype NMV P199427—ORCQ	0.03	0.06
Paratype NMV P199428—BON 36–39	0.06	0.12

Distribution. OTRC 5, OTRC 7, Ma 13, BON 13.5–15, BON 29–35, BON 36–39, ORCQ 10–15; *dehiscens–inversus* zones; also known from the Upper Silurian (Ludlow) of Eastern Victoria (Simpson et al. 1993).

Remarks. This species is very similar to *T. nexuosa* Crespin from the Australian Upper Devonian but differs in having a rough unpolished surface. It appears closest to *T. bransoni* Conkin et al. 1968 from the Mississippian of Missouri but differs in showing little or no evidence for a basal floor. As is usual with many of the tolypamminids the shape of the second chamber is highly variable. Kazmierczak (1973) found *Tolypammina* to live within the water channels of sponges and so the constrictions on its mode of growth cause the great variability in morphology shown by this genus. Apart from very rare *Receptaculites* no sponges are known from the Buchan Caves Limestone or Taravale Formation.

Derivation of name. *anguinea* (L.): snaky.

Tolypammina tantula n. sp.

Fig. 10C–E

Description. Test free; a long cylindrical tube which expands from a small, egg-shaped proloculum; chamber walls usually entire, made of coarse grains, roughly finished; aperture at end of tube.

Holotype. NMV P126995; from Bonanza Gully, Bindi, sample BON 13.5–15, Buchan Caves Limestone.

Measurements (in mm)	proloculum diam.	aperture
Holotype NMV P126995	0.036	0.1
Paratype NMV P199903—BON 29–35	0.07	0.09

Distribution. BON 13.5–15, BON 29–35, BON 36–39; OTRC 5, OTRC 7; *perbonus* Zone.

Remarks. This is a more robust species than *T. anguinea* n.sp. from which it differs in having a completely tubular second chamber with no apparent indication of attachment to a substrate, in the normally non-meandering habit of growth and in the tiny proloculum. Specimens with a proloculum are rare; the early part of the test is thin and fragile compared to the later more robust section.

Derivation of name. *tantula* (L.): so small; referring to the proloculum and initial part of test.

Genus **Ammovertella** Cushman, 1928

Ammovertella calyx n.sp.

Figs 4, 10F–I

Description. Test originally attached; small; hemispherical to hemiellipsoidal proloculum followed by a hemitubular second chamber which encircles the proloculum for about three-quarters of a turn, and then becomes sinuous and ultimately rectilinear; test wall made of small sand grains, several grains in thickness, coarsely finished outside but the interior surface smooth; the attached surface is flat, without any floor along its entire length; aperture is a simple tubular opening at the end of the second chamber.

Holotype. NMV P126989, from Bonanza Gully, Bindi, sample 13.5–15, Buchan Caves Limestone.

Measurements (in mm)	proloculum diam.	length
Holotype NMV P126989	0.02	0.27
Paratype NMV P199429–BON 13.5–15	0.02	0.21
Paratype NMV P199430–BON 13.5–15	0.03	0.4

Distribution. BON 13.5–15, ORCQ 10–15; *perbonus* Zone.

Remarks. Because of the partly enrolled second chamber this species is placed in the genus *Ammovertella*. In some specimens there was a small flange on the wall edge at the attachment point. There was a large variation in the degree of coiling, the thickness of chamber walls, in the chamber diameter and, subsequently, in the shape of the test (Figs 4, 10F–I). Very rare specimens were found with a more enrolled early chamber development (Fig. 4E). These variations possibly only reflect the influence of the attachment surface and the surrounding environmental factors (Atkinson 1969).

Derivation of name. *calyx* (L.): limestone.

Genus **Lituotuba** Rhumbler 1895

Loeblich & Tappan (1988: 69) have stated, without giving reasons, that the Palaeozoic forms previously placed in *Lituotuba* are not congeneric with that genus. Until reasons for this change are given I have retained the genus for Early Devonian species from Victoria but have written it as '*Lituotuba*'.

'Lituotuba' torquata n.sp.

Fig. 9H

Description. Test free; early stage is a bulbous proloculum followed by an almost planispiral coiled undivided cylindrical tube of more or less one turn; in the later stage the tube becomes an uncoiled, undivided rectilinear segment with an helical twist of two (or more) turns imposed upon it; test wall fine grained, fairly smoothly finished; the aperture is a simple opening at the end of the linear segment.

Holotype. NMV P126990, from Old Taravale Road cutting, Buchan, sample 7, Taravale Formation.

Measurements (in mm)	length	width	neck width
Holotype NMV P126990	0.43	0.26	0.08
Paratype NMV P199431 –BON13.5–15	0.4	0.22	0.08

Fig. 10. A–B, *Tolypammina anguinea* Bell n.sp. A, Holotype, NMV P126988, ×180, ORCQ 10–15, attached side view. B, Paratype, NMV P199427, ×72, ORCQ 10–15, dorsal view. C–E, *Tolypammina tantula* Bell n.sp. C, Paratype, NMV P199903, ×63, BON 29–35, attached surface view. D, Holotype, NMV P126995, ×54, BON 13.5–15, dorsal view. E, Paratype, NMV P199902, ×72, BON 13.5–15, dorsal view. F–I, *Ammovertella calyx* Bell n.sp. F, Holotype, NMV P126989, ×180, BON 13.5–15, attached surface view. G, Paratype, NMV P199429, ×90, BON 13.5–15, dorsal view. H, Paratype, NMV P199430, ×135, BON 13.5–15, attached surface view. I, Paratype, NMV P199901, ×270, BON 13.5–15, attached surface view, arrow indicates double wall. J–K, *Webbinelloidea crassus* Bell n.sp. J, Holotype, NMV P126983, ×110, BON 206, oblique view of attached surface. K, Paratype, NMV P199900, ×90, oblique view of attached surface, arrow indicates small attachment aperture. L, *Thuramminopsis sphaeroidalis* Plummer, NMV P126987, ×54, OTRC 7.


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Distribution. OTRC 7, BON 13.5–15; *dehiscens–perbonus* zones.

Remarks. The distinctive twisted neck easily distinguishes this species from other Palaeozoic '*Lituotuba*' spp. The degree of twisting is variable but is always present.

Derivation of name. *torquata* (L.): wearing a twisted collar.

'Lituotuba' helix n.sp.

Fig. 9I

Description. Test free; initially a small rounded proloculum followed by an unsegmented cylindrical tube of two and one half whorls helically arranged, then uncoiling and becoming rectilinear; test wall fine grained, surface smoothly finished; aperture a simple opening at the end of the tube.

Holotype: NMV P126991, from Old Taravale Road cutting, Buchan, sample 5, Taravale Formation.

Measurements (in mm)	length	width	aperture
Holotype NMV P126991	0.53	0.2	0.08

Distribution. Known from the type locality only, OTRC 5; *dehiscens* Zone.

Remarks. This species is readily distinguished by the early helix-form of the test.

Derivation of name. *helix* (L.): referring to the early whorl shape.

Family HORMOSINIDAE Haeckel, 1894

Genus Hormosina Brady, 1879

Hormosina divitiae n.sp.

Fig. 9J

Description. Test free; small; multilocular with oblate, thin-walled chambers gradually increasing in size, arranged rectilinearly; sutures constricted and well marked; wall finely agglutinate and smoothly finished; aperture terminal, rounded, on a slightly produced neck.

Holotype. NMV P126992, from Bonanza Gully, Bindi, sample 220–240, Buchan Caves Limestone.

Measurements (in mm)		length	width	aperture
Holotype NMV P126992	ch. 1:	0.11	0.22	
	ch. 2:	0.15	0.23	
	ch. 3:	0.18	0.23	0.09

Distribution. Known only from the type locality, BON 220–240; *perbonus* Zone.

Remarks. This species is placed in the genus *Hormosina* because of its rectilinear form, thin walled chambers and produced apertural neck, even though the chambers are not spherical which has been considered a diagnostic feature of *Hormosina* (Bronnimann & Whittaker, 1980). Previously *Hormosina* was only known to range from Jurassic to Recent (Loeblich & Tappan 1988).

Derivation of name. *divitiae* (L., f., pl.): riches, bonanza; referring to the locality, Bonanza Gully.

Genus Reophax Montfort, 1808 emend. Bronnimann and Whittaker, 1980

Reophax troca n.sp.

Fig. 9G

Description. Test free; small; multilocular, uniserial arrangement of chambers in a slightly arcuate chain; initial chamber fairly large, globular, with successive chambers slightly oblate, increasing in size; sutures clearly defined, slightly oblique; aperture terminal, rounded, on a very short wide neck; test formed of moderate sized grains, somewhat roughly finished.

Holotype. NMV P126993, from Old Taravale Road cutting, Buchan, sample 7, Taravale Formation.

Measurements (in mm)	length	width	aperture
Holotype NMV P126993	0.28	ch 1: 0.08	
		ch 2: 0.12	0.03

Distribution. Known from the type locality only, OTRC 7; *dehiscens* Zone.

Remarks. Because of the non-symmetrical chambers and their asymmetrical arrangement this species is placed in *Reophax* as emended by Bronnimann & Whittaker (1980) not in *Hormosina* notwithstanding the presence of a short terminal neck.

Although the genus *Reophax* is known from the Ordovician no previous Early Devonian specimens have been reported (Gutschick 1986) although microforaminiferal organic linings from the Pragian (*sulcatus* Zone) of New South Wales, Australia, have been referred to this genus (Winchester-Seeto & Bell 1994).

Derivation of name. *troca*: anagram of locality, Old Taravale Road cutting.

INCERTAE SEDIS

Genus Thuramminoides Plummer, 1945

Thuramminoides sphaeroidalis Plummer, 1945

Fig. 10

Thuramminoides sphaeroidalis Plummer 1945: 218, pl. 15, figs 4–10.

Figured specimen. NMV P126987, from OTRC 7, Old Taravale Road cutting, Buchan; Taravale Formation.

Measurement (in mm)
Figured specimen NMV P126987 diameter: 0.56

Distribution. dehiscens–serotinus zones.

Remarks. This species was very widespread and was found in many samples which contained no foraminiferans.

It was more common in the sandier samples from Old Taravale Road cutting (OTRC) and at south arm, Limestone Creek, Bindi, (SALC), but infrequent in the purer limestones of Bonanza Gully (BON) and Old Rocky Camp Quarry (ORCQ 10–15). Specimens were always compressed and often split.

Trochammina bursaria, which Chapman (1933) described from possible Lower Devonian mudstones near Mitcham, Victoria (registered specimen NMV P26009, Museum of Victoria Palaeontology Collection), is identical to forms placed here in *T. sphaeroidalis*; the supposed 'internal tubular chamber' of Chapman's species is just a compressional effect.

Although described by Plummer (1945) as a foraminiferan, this species has been remarked as having spore-like affinities (Conkin et al. 1965) and also has been referred to the radiolaria (Conkin et al. 1968; Conkin et al. 1981).

FACIES DEPENDENCE OF FAUNA

Whilst the distinction between the limestones and marly limestones facies is not clear cut due to the varying amounts of argillaceous material found in the calcareous sediments, the faunas can be broadly separated into species mainly characteristic of the limestones (28 spp.) and those of the more muddier sediments (2 spp.), whilst 15 spp. occurred in both facies (Table 2). The genera *Thurammina*, *Sorosphaera*, *Kerionammina*, *Saccammina*, *Patellammina*, *Hormosina*, *Ammovertella*, *Metamorphina*, *Ordovicina* and *Hemisphaerammina* were only found in the limestones. Of the other genera in the fauna, some species within each genus had a restricted facies distribution e.g. *Cystingarhiza* where three species were present in both facies but *C. mawsonae* was only found in the muddier phases, and *Hyperammina* where *H. reflua* was only present in the purer limestones but *H. proboscis* was present in both phases. *Lagenammina* spp. were found in both facies but predominately in the muddier phases; in present day seas *Lagenammina* occurs mainly in the 20–50 m zone under moderately reducing conditions (Sellier de Civrieux & Ruiz 1971). *Tolypammina* spp., although present in both facies, were much more common in the limestone facies. Overall the forms found only in the limestones include those considered to belong to a mixed energy, perhaps high turbulence, environment (McClellan 1966, 1973). However many more data are required before facies dependence of many of the species and genera can be confidently accepted although it would seem that some of the species found can tolerate lower oxygen conditions than others. The rate of deposition of the Taravale formation was probably rapid leading to a high input of organic material and so

Limestone facies	*Thurammina subsphaerica*	Cosmopolitan
Psammosphaera cava	*Thurammina tributa*	*Astrorhiza triquetra*
Rhabdammina proavita	*Thurammina foerstei*	*Astrorhiza constans*
Saccorhiza surculus	*Thurammina zaramama*	*Astrorhiza sinus*
Stomasphaera cyclops	*Ordovicina eisenacki*	*Cystingarhiza corona*
Soros-jaera sp. cf. *S. confusa*	*Kerionammina prolata*	*Cystingarhiza tribrachia*
Saccammina biosculata	*Lituotuba helix*	*Cystingarhiza furca*
Saccammina cumberlandiae	*Lituotuba torquata*	*Cylindrammina stolonifera*
Stegnammina cylindrica	*Tolypammina tanula*	*Rhabdammina linearis*
Webbinelloidea crassus	*Ammovertella calyx*	*Hyperammina proboscis*
Hemisphaerammina sp.	*Hormosina divitiae*	*Pelosina grandaeva*
Metamorphina tholus	*Reophax troca*	*Lagenammina sphaerica*
Patellammina prona	*Thuramminoides sphaeroidalis*	*Lagenammina talenti*
Hyperammina reflua	Muddy facies	*Lagenammina laxacolla*
Hyperammina sp.	*Cystingarhiza mawsonae*	*Lagenammina ovata*
Thurammina echinata	*Lagenammina stilla*	*Tolypammina anguinea*

Table 2. Distribution of species within the various facies.

a greater bacterial decay rate and subsequent oxygen depletion which would limit the species present.

DISCUSSION

This study has shown that the lower Devonian deposits in southeastern Australia have a large and varied foraminiferal fauna. Foraminifera were never common in any of the samples—approximately 10 per kg of sediment treated, which can be compared with other Lower Palaeozoic reported findings of about 25/kg (Gutschick 1988), about 100/kg (Browne & Schott 1963) and about 85/kg (Ireland 1966). Nevertheless it was apparent that in samples which contained little or no fine silt or sandy fraction (the sparry bioclastics) the foraminiferans were extremely rare whereas in the more sandy/clayey samples the foraminiferal fauna was markedly richer; this relative abundance of the agglutinated foraminifers shows the importance of lithology in the study of Palaeozoic foraminiferal faunas—a point also made by Conkin (1961) and Conkin & Conkin (1964b). Also it was apparent (but not investigated quantitatively) that there was an almost inverse relation between the abundances of foraminifera and conodonts; this relationship between foraminifera and conodonts has been previously remarked upon (Cushman & Stainbrook 1943). The numbers, and indeed the presence, of a species can depend upon the acid treatment the rocks received (Gutschick 1986); this point has not been addressed in this study as all samples had been acetic acid treated when received.

The numbers of genera and species are similar to those described for other parts of the world, although the faunas show significant differences e.g. the presence in Victorian faunas of *Cystingarhiza* and *Astrorhiza* but the lack of *Ammodiscus*. Whether this is an age or facies difference is not yet apparent and must await further work on the Australian faunas.

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REFERENCES

Adegoke, D. S., Dessauvagie, T. F. J. & Yoluye, V. L. A., 1969. *Hemisphaerammina*-like egg capsules of Neritina (Gastropoda) from Nigeria. *Micropaleontology* 15: 102–106.

Atkinson, K., 1969. The association of living foraminifera with algae from the littoral zone, south Cardigan Bay. *Journal of Natural History* 3: 517–542, text-figs 1–6.

Barnard, T. A., 1958. Some Mesozoic adherent foraminifera. *Palaeontology* 1(2): 116–124.

Bell, K. N. & Burn, R. F., 1979. On the identity of *Webbinella bassensis* Parr. *The Victorian Naturalist* 96: 198–199.

Bermudez, P. J. & de Rivero, F. C., 1963. Estudio Sistematico de los Foraminiferos Quitinosos, Microgranulares y Arenaceos. Universidad Central de Venezuela, Caracas. 398 pp.

Brady, H. B., 1879. Notes on some of the Reticularian Rhizopoda of the Challenger Expedition. 1. On new or little known arenaceous types. *Quarterly Journal of Microscopical Science* 19: 20–63, 3 pls.

Brady, H. B., 1884. Report on the foraminifera dredged by H.M.S. "Challenger" during the years 1873–1876. *Report, voyage of the Challenger, Zoology* 9, pp. 1–814, pls 1–115.

Bronnimann, P. & Whittaker, J. E., 1980. A revision of *Reophax* and its type species, with remarks on several other Recent hormosinid species (Protozoa: Foraminiferida) in the collections of the British Museum (Natural History). *British Museum, Natural History, Bulletin (Zoology)* 39(5): 259–272.

Browne, R. G. & Schott, Y. J., 1963. Arenaceous foraminifera from the Osgood Formation, at Osgood, Indiana. *Bulletins of American Paleontology* 46: 191–242.

Buchanan, J. A., 1960. On Jullienella and Schizammina, two genera of arenaceous foraminifera from the tropical Atlantic. *Journal of the Linnean Society of London* 44: 270–277.

Chapman, F. A., 1933. Some Palaeozoic fossils from Victoria. *Proceedings of the Royal Society of Victoria* 45: 242–248.

Conkin, J. E., 1961. Mississippian smaller foraminifera of Kentucky, southern Indiana, northern Tennessee and south-central Ohio. *Bulletins of American Paleontology* 43: 131–368.

Conkin, J. E. & Conkin, B. M., 1964a. Mississippian foraminifera of the United States. Part 1—The Northview Formation of Missouri. *Micropaleontology* 10: 19–47, pls 1, 2.

Conkin, J. E. & Conkin, B. M., 1964b. Devonian foraminifera: Pt 1, The Louisiana limestone of Missouri and Illinois. *Bulletins of American Paleontology* 47: 53–105.

Conkin, J. E. & Conkin, B. M., 1968. A revision of some Upper Devonian foraminifera from Western Australia. *Palaeontology* 11: 601–609.

Conkin, J. E. & Conkin, B. M., 1982. North American Paleozoic agglutinate foraminifera. In *Foraminifera, Notes for a short course*, M. A. Buzas & B. K. Sen Gupta, eds, University of Tennessee, Dept Geological Science, Studies in Geology 6: 177–191.

Conkin, J. E., Conkin, B. M. & Canis, W. F., 1968. Mississippian foraminifera of the United States. Pt. 3: The limestones of the Chouteau Group in Missouri and Illinois. *Micropaleontology* 14: 133–178.

Conkin, J. E., Conkin, B. M. & McDonald, D., 1963. Mississippian smaller foraminifera from the southern peninsula of Michigan. *Micropaleontology* 9: 215–227, pl. 1.

Conkin, J. E., Conkin, B. M. & Pike, J. W., 1965. Mississippian foraminifera, Pt. 2: The Hannibal Formation of Missouri and western Illinois. *Micropaleontology* 11: 335–359.

Conkin, J. E., Conkin, B. M., Walton, M. M. & Neff, E. D., 1981. Devonian and early Mississippian smaller foraminiferans of southern Indiana and northwest Kentucky. Field Trip No. 2, Geological Society of America, Annual Meeting, Cincinnata, Ohio. 25 pp.

Cushman, J. A., 1905. Developmental stages in the Lagenidae. *The American Naturalist* 39: 537–553.

Cushman, J. A. & Stainbrook, M. A., 1943. Some foraminifera from the Devonian of Iowa. *Cushman Laboratory for Foraminiferal Research, Contributions*, 19: 73–79.

Dunn, P. H., 1942. Silurian foraminifera of the Mississippi Basin. *Journal of Paleontology* 16: 317–342.

Earland, A., 1933. Foraminifera. Part 2, South Georgia. *Discovery Reports, Vol.* 7: 27–138.

Fletcher, K., 1963. The Snowy River Volcanics west of Buchan, Victoria. *Proceedings of the Royal Society of Victoria* 76: 169–179, 1 pl.

Gaskin, A. J., 1933. The geology of Bindi, Victoria. *Proceedings of the Royal Society of Victoria* 55: 81–105.

Geroch, S., 1955. Saccamminoides, nowa otwornica z Eocenu Kapat Fliszowych. *Polskiego Towarzystwa Geologicznego, Rocznik* 23: 53–63.

Gutschick, R. C., 1986. Middle Ordovician agglutinated foraminifera including *Reophax* from the Mifflin Formation Platteville Group of Illinois. *Journal of Paleontology* 60: 233–248.

Gutschick, R. C. & Treckman, J. F., 1959. Arenaceous foraminifera from the Rockford limestone of northern Indiana. *Journal of Paleontology* 33: 229–250.

Hayward, B. W. & Gordon, D. P., 1984. A new species of the agglutinated foraminifer *Jullienella* (Schizamminidae) from New Zealand. *Journal of Foraminiferal Research* 14: 111–114.

Henbest, L. G., 1963. Biology, mineralogy and diagenesis of some typical Late Paleozoic sedentary Foraminifera and Algal-foraminiferal colonies. *Cushman Foundation for Foraminiferal Research. Special Publication* 6.

Hill, D., 1950. Middle Devonian corals from the Buchan district, Victoria. *Proceedings of the Royal Society of Victoria* 66: 137–164.

Hofker, J., 1972. *Primitive Agglutinated Foraminifera.* E. J. Brill, Leiden. 95 pp.

Ireland, H. A., 1956. Upper Pennsylvanian arenaceous foraminifera, Kansas. *Journal of Paleontology* 30: 831–864.

Ireland, H. A., 1966. Silurian arenaceous foraminifera from subsurface strata of N-E Kansas. *Micropaleontology* 12: 215–234.

Kazmierczak, J., 1973. *Tolypammina vagans* (Foraminiferida) as inhabitant of the Oxfordian Siliceous Sponges. *Acta Paleontologica Polonica* 18: 95–115.

Krommelbein, K., 1954. Devonische ostracoden aus der gegend von Buchan und von der Kuste der Waratah Bay, Victoria, Australien. *Senckenbergiana Lethaea* 35: 193–229.

Loeblich, A. R. & Tappan, H., 1988. Foraminiferal Genera and their Classification. Van Nostrand Reinhold Co., New York. 2 vols, 2047 pp.

Loeblich, A. R. & Tappan, H., 1994. Foraminifera of the Sahul Shelf and Timor Sea. *Cushman Foundation for Foraminiferal Research, Special Publication* 31, 661 pp.

McClellan, W. A., 1966. Arenaceous Foraminifera from the Waldron Shale (Niagran) of S-E Indiana. *Bulletins of American Paleontology* 50: 444–518.

McClellan, W. A., 1973. Siluro-Devonian Microfaunal Biostratigraphy in Nevada. *Bulletins of American Paleontology* 62: 233–375.

Malec, J., 1992. Arenaceous foraminifera from Lower–Middle Devonian boundary beds of western part of the Gory Swietokrzyskie Mtns. *Annales Societatis Geologrum Poloniae* 62: 269–287.

Mawson, R., 1987a. Early Devonian conodont faunas from Buchan and Bindi, Victoria, Australia. *Palaeontology* 30: 247–293.

Mawson, R., 1987b. Documentation of conodont assemblages across the Early Devonian–Middle Devonian boundary, Broken River Formation, North Queensland, Australia. *Courier Forschungsinstitut Senckenberg* 92: 251–273.

Mawson, R., Jell, J. S. & Talent, J. A., 1985. Stage boundaries within the Devonian: Implications for application to Australian sequences. *Courier Forschungsinstitut Senckenberg* 75: 1–16.

Mawson, R., Talent, J. A., Brock, G. A. & Engelbretsen, M. J., 1993. Conodant data in relation to sequences about the Pragian–Emsian boundary (Early Devonian) in South-eastern Australia. *Proceedings of the Royal Society of Victoria* 104: 23–56.

Moreman, W. L., 1930. Arenaceous foraminifera from the Ordovician and Silurian of Oklahoma. *Journal of Paleontology* 4: 42–59.

MOREMAN, W. L., 1933. Arenaceous foraminifera from the lower Paleozoic rocks of Oklahoma. *Journal of Palaeontology* 7: 393–397.

NORVANG, A., 1961. Schizamminidae, A new family of Foraminifera. *Atlantide Report* 6: 169–201, 4 pls.

PEDDER, A. E. H., 1967a. *Lyrielasma* and a new related genus of Devonian tetracorals. *Proceedings of the Royal Society of Victoria* 80: 1–30.

PEDDER, A. E. H., 1967b. Lower Devonian Streptelasmatid, Linstroemiid and possible Amplexocariniid corals from Victoria. *Proceedings of the Royal Society of Victoria* 80: 107–130.

PHILIP, G. M., 1966. Lower Devonian conodonts from the Buchan Group, eastern Victoria. *Micropaleontology* 12: 441–460.

PLUMMER, H. J., 1945. Smaller foraminifera in the Marble Falls, Smithwick and lower Strawn strata around the Llano uplift in Texas. *University of Texas, Publication* 4401: 209–271.

RIPPER, E. A., 1937. On the Stromatoporoids of the Buchan District. *Proceedings of the Royal Society of Victoria* 50: 12–38.

SELLIER DE CIVRIEUX, J. M. & RUIZ, J. B., 1971. La influencia de los parametros fisico-quimicos del fondo en las facies de foraminiferos bentonicos. *Boletin, Instituto Oceanografico Universidad de Oriente* 10: 15–34.

SHCHEDRINA, Z. G., 1969. O nekotorykh iz memeniyakh v sisteme semeystv Astrorhizidae i Reophacidae (Foraminifera). [On some changes in the systematics of the families Astrorhizidae and Reophacidae (Foraninifera)]. *Voprosy Mikropaleontologii* 11: 157–170.

SIMPSON, A. J., BELL, K. N., MAWSON, R. & TALENT, J. A., 1993. Late Silurian (Ludlow) conodonts and foraminifers from Cowombat, SE Australia. *Memoir, Association of Australasian Palaeontologists* 15: 141–159.

STEWART, G. A. & LAMPE, L., 1947. Foraminifera from the Middle Devonian bone beds of Ohio. *Journal of Paleontology* 21: 529–536.

TALENT, J. A., 1956. Devonian brachiopods and pelecypods from the Buchan Caves Limestone, Victoria. *Proceedings of the Royal Society of Victoria* 68: 1–56.

TALENT, J. A., 1965. The stratigraphic and diastrophic evolution of central and eastern Victoria in Middle Palaeozoic times. *Proceedings of the Royal Society of Victoria* 79: 179–195.

TALENT, J. A., 1967. Eastern Victoria. *Australian-New Zealand Association for the Advancement of Science, Excursion Handbook*, Section C: 69–85.

TALENT, J. A., 1969. The geology of East Gippsland. *Proceedings of the Royal Society of Victoria* 82: 37–60.

TALENT, J. A., 1989. Transgression-Regression Pattern for the Silurian and Devonian of Australia. In *Pathways in Geology: essays in honour of Edwin Sherbon Hills*, R. W. LeMaitre, ed., Blackwells, Melbourne, 201–219.

TEICHERT, C., 1948. Middle Devonian goniatites from the Buchan district, Victoria. *Journal of Paleontology* 22: 60–67.

TEICHERT, C. & TALENT, J. A., 1958. Geology of the Buchan area, East Gippsland. *Geological Survey of Victoria, Memoir* 21, 56 pp.

VANDENBERG, A. H. M., 1988. Silurian–Middle Devonian. In *Geology of Victoria*, J. G. Douglas & J. A. Ferguson, eds, Geological Society of Australia, Melbourne, 103–146.

WEBBY, B. D., STEARN, C. W. & ZHEN, Y. Y., 1993. Lower Devonian (Pragian–Emsian) stromatoporoids from Victoria. *Proceedings of the Royal Society of Victoria* 105: 113–185.

WINCHESTER-SEETO, T. & BELL, K. N., 1994. Microforaminiferal linings from the Early Devonian of Eastern Australia, and their generic placement. *Journal of Paleontology* 68: 200–207.

WHYMPER, E., 1892. Travels amongst the Great Andes of the Equator. C. Shribner's Sons, New York. 456 pp.